



US009474498B2

(12) **United States Patent**  
**Zan**

(10) **Patent No.:** **US 9,474,498 B2**  
(45) **Date of Patent:** **\*Oct. 25, 2016**

(54) **INTEGRATED MULTI-RAIL IMAGING SYSTEM**

(71) Applicant: **FUJIFILM SonoSite, Inc.**, Bothell, WA (US)

(72) Inventor: **Leo Zan**, Toronto (CA)

(73) Assignee: **FUJIFILM SonoSite, Inc.**, Bothell, WA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/576,113**

(22) Filed: **Dec. 18, 2014**

(65) **Prior Publication Data**

US 2015/0173702 A1 Jun. 25, 2015

**Related U.S. Application Data**

(63) Continuation of application No. 13/324,996, filed on Dec. 13, 2011, now Pat. No. 8,945,014, which is a continuation of application No. 11/053,748, filed on Feb. 7, 2005, now Pat. No. 8,078,256, which is a

(Continued)

(51) **Int. Cl.**

**A61B 5/055** (2006.01)

**A61B 6/04** (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ..... **A61B 6/508** (2013.01); **A61B 5/0555** (2013.01); **A61B 6/032** (2013.01); **A61B 6/0457** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC A61B 8/4209; A61B 8/0841; A61B 8/0833; A61B 6/12; A61B 5/0555; A61B 6/508; A61B 6/032; A61B 6/44; A61B 6/0457; A61B 8/4461; A61B 8/40; A61B 19/201; A61D 3/00

USPC ..... 600/415, 459; 119/722

See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

1,573,571 A 2/1926 Pohl  
1,599,134 A 9/1926 King

(Continued)

**FOREIGN PATENT DOCUMENTS**

FR 2670097 A1 6/1992  
JP 55003740 Y2 1/1980

(Continued)

**OTHER PUBLICATIONS**

Foster, F.S. et al. "A new ultrasound instrument for in vivo microimaging of mice," *Ultrasound in Medicine & Biology*, vol. 28, Issue 9, Sep. 2002, pp. 1165-1172.

(Continued)

*Primary Examiner* — Long V Le

*Assistant Examiner* — Angela M Hoffa

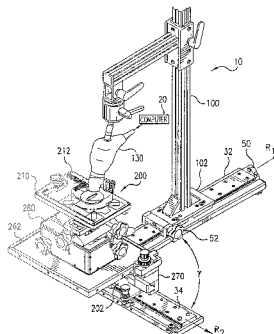
(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57)

**ABSTRACT**

The imaging system can comprise a plurality of elongated rails, a scanhead assembly, and a small animal mount assembly. The scanhead assembly is selectively mounted onto a first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail. The small-animal mount assembly is selectively mounted onto a second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail. The second rail being mounted relative to the first rail such that the longitudinal axis of the second rail is at an angle to the longitudinal axis of the first rail. The imaging system can also comprise a needle injection assembly that is selectively mounted onto the third rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail. The third rail being mounted relative to the second rail and the first rail such that the longitudinal axis of the third rail is substantially coaxial to the longitudinal axis of the first rail. Alternatively, the needle injection assembly is mounted onto the first rail, such that the second rail is positioned therebetween the needle injection assembly and the scanhead assembly.

**20 Claims, 67 Drawing Sheets**



**Related U.S. Application Data**

- continuation-in-part of application No. 10/683,168, filed on Oct. 10, 2003, now Pat. No. 7,133,713.
- (60) Provisional application No. 60/417,167, filed on Oct. 10, 2002, provisional application No. 60/468,959, filed on May 9, 2003, provisional application No. 60/468,960, filed on May 9, 2003.
- (51) **Int. Cl.**  
*A61B 8/00* (2006.01)  
*A61B 6/00* (2006.01)  
*A61B 8/08* (2006.01)  
*A61B 6/03* (2006.01)  
*A61B 19/00* (2006.01)  
*A61D 3/00* (2006.01)  
*A61B 6/12* (2006.01)
- (52) **U.S. Cl.**  
 CPC ..... *A61B 6/44* (2013.01); *A61B 8/0833* (2013.01); *A61B 8/0841* (2013.01); *A61B 8/40* (2013.01); *A61B 8/4209* (2013.01); *A61B 8/4461* (2013.01); *A61B 90/11* (2016.02); *A61B 6/12* (2013.01); *A61D 3/00* (2013.01)
- (56) **References Cited**

**U.S. PATENT DOCUMENTS**

2,789,538	A	4/1957	Merritt
2,828,172	A	3/1958	McDonald
3,028,836	A	4/1962	Strauss
3,120,836	A	2/1964	Brauning
3,327,656	A	6/1967	Schwartz
3,474,763	A	10/1969	Kissil et al.
3,476,104	A	11/1969	Davis
3,685,779	A	8/1972	Papritz
3,720,209	A	3/1973	Bolduc
3,888,240	A	6/1975	Reinhold, Jr. et al.
3,970,046	A	7/1976	Boggs
4,082,086	A	4/1978	Page et al.
4,148,280	A	4/1979	Masuda et al.
4,257,349	A	3/1981	Carlin
4,365,561	A	12/1982	Tellier et al.
4,672,697	A	6/1987	Schuerch
4,779,540	A	10/1988	Dion
4,842,259	A	6/1989	Rice
5,020,520	A	6/1991	Lawlis
5,022,762	A	6/1991	Stroud et al.
5,104,621	A	4/1992	Pfost et al.
5,138,138	A	8/1992	Theilacker et al.
5,163,380	A	11/1992	Duffy et al.
5,168,634	A	12/1992	Misevich
5,309,847	A	5/1994	Matsumoto
5,324,911	A	6/1994	Cranston et al.
5,826,286	A	10/1998	Cranston
5,915,334	A	6/1999	Cummings et al.
5,985,214	A	11/1999	Stylli et al.
6,001,309	A	12/1999	Gamble et al.
6,155,260	A	12/2000	Lavin et al.
6,225,631	B1	5/2001	Mastrippolito et al.
6,258,103	B1	7/2001	Saracione
6,275,723	B1	8/2001	Ferris et al.
6,327,982	B1	12/2001	Jackson
6,445,941	B1	9/2002	Hampton et al.
6,520,093	B1	2/2003	Merl
6,627,446	B1	9/2003	Roach et al.
6,653,607	B2	11/2003	Ellis et al.
6,685,884	B2	2/2004	Stylli et al.
6,710,798	B1	3/2004	Hershel et al.
6,711,430	B1	3/2004	Ferris et al.
6,764,648	B1	7/2004	Roach et al.
6,789,510	B1	9/2004	Lee
6,840,180	B2	1/2005	Ulmer
6,851,392	B2	2/2005	Zan et al.
6,869,593	B2	3/2005	Frangioni
6,873,156	B2	3/2005	Ferris et al.
6,890,485	B1	5/2005	Stylli et al.

6,924,467	B2	8/2005	Ellis et al.
7,096,059	B2	8/2006	Geddes et al.
7,133,713	B2	11/2006	Zan
7,190,991	B2	3/2007	Cable et al.
7,223,018	B2	5/2007	Kanehira
7,337,751	B2	3/2008	Lopez et al.
7,352,889	B2	4/2008	Ganz et al.
7,380,299	B1	6/2008	DeMayo
7,414,403	B2	8/2008	Chiodo
7,426,904	B2	9/2008	Zan et al.
7,434,542	B2	10/2008	Zan et al.
7,865,226	B2	1/2011	Chiodo
8,078,256	B2	12/2011	Zan
8,334,698	B2	12/2012	Tammer et al.
8,401,620	B2	3/2013	Velusamy et al.
8,945,014	B2	2/2015	Zan
2002/0012611	A1	1/2002	Stylli et al.
2002/0112672	A1	8/2002	Schafhalter
2003/0069471	A1	4/2003	Nakanishi et al.
2003/0094123	A1	5/2003	Ulmer
2003/0111021	A1	6/2003	Lee
2003/0166996	A1	9/2003	Kim et al.
2004/0028611	A1	2/2004	Frangioni
2004/0102705	A1	5/2004	Zan et al.
2004/0122324	A1	6/2004	Zan
2004/0131234	A1	7/2004	Long et al.
2004/0206419	A1	10/2004	Ganz et al.
2005/0010121	A1	1/2005	Ross et al.
2005/0039699	A1	2/2005	Sato et al.
2005/0197543	A1	9/2005	Zan et al.
2005/0215878	A1	9/2005	Zan
2006/0078501	A1	4/2006	Goertz et al.
2007/0131149	A1	6/2007	Mayben
2007/0185396	A1	8/2007	Zan
2008/0015420	A1	1/2008	Zan et al.
2009/0000567	A1	1/2009	Hadjoannou et al.
2012/0316404	A1*	12/2012	Zan ..... A61B 8/0833 600/301
2013/0184572	A1	7/2013	Velusamy et al.

**FOREIGN PATENT DOCUMENTS**

JP	2249536	10/1990
JP	3077552	4/1991
JP	H4-40942	2/1992
JP	4256734	B2 9/1992
JP	08047501	B3 2/1996
JP	09187192	B7 7/1997
JP	11221242	B4 8/1999
JP	2001503627	B6 3/2001
JP	2002051662	B2 2/2002
JP	2002224051	B1 8/2002
JP	2002263076	B5 9/2002
WO	0232306	4/2002
WO	2004032725	4/2004

**OTHER PUBLICATIONS**

International Searching Authority, International Preliminary Examination Report, PCT Application No. PCT/US 2003/032437, completed Mar. 3, 2006, 8 pages.

International Searching Authority, International Search Report, PCT Application PCT/US2003/032437, mailed Sep. 10, 2004, 1 page.

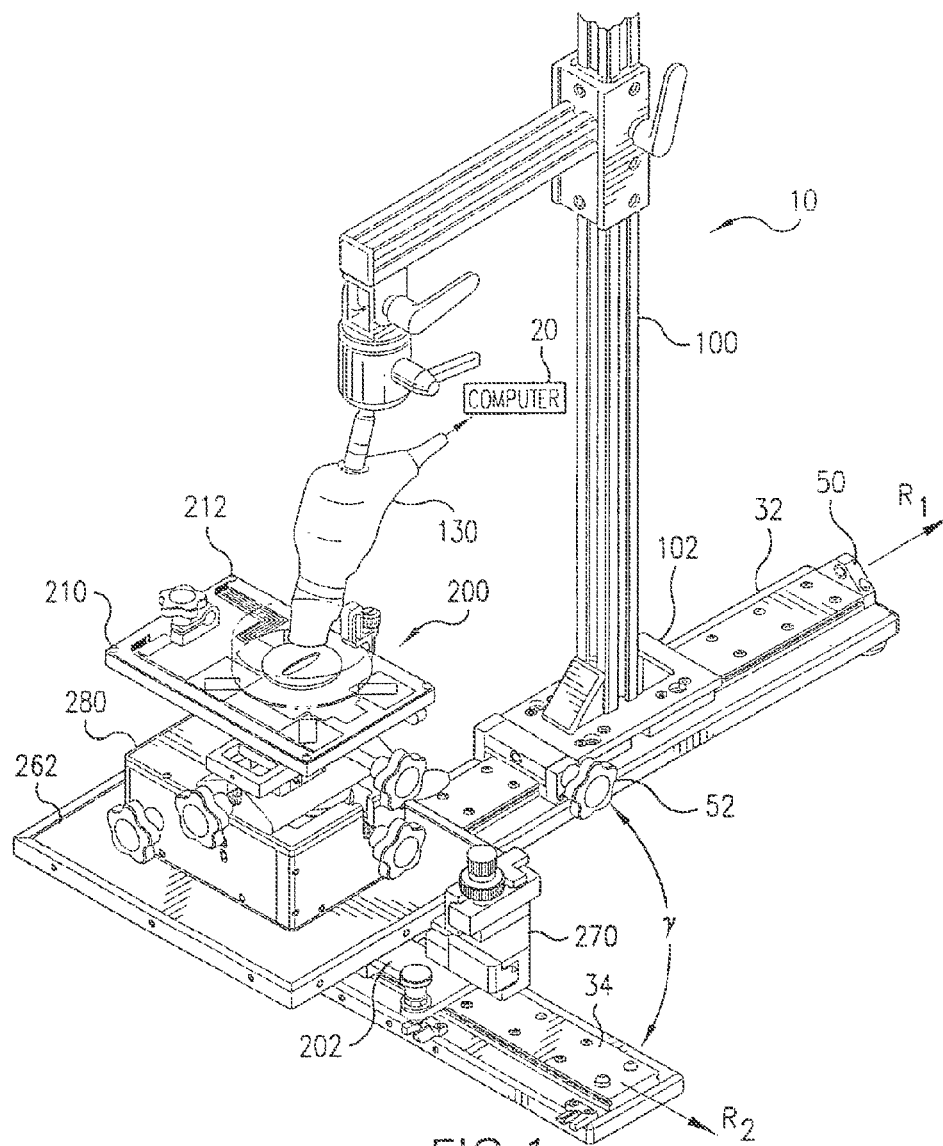
International Searching Authority, Supplementary European Search Report, European Patent Application 03774811.8, mailed Nov. 27, 2008, 5 pages.

Japan Patent Office, Notice of Reasons for Rejection, JP Patent Application 2009-098634, mailed Jan. 10, 2012, 7 pages.

Turnbull, D.H. et al. "In vivo ultrasound biomicroscopy in developmental biology," *Trends in Biotechnology*, vol. 20, No. 8 (suppl.), 2002, pp. S29-S33.

VisualSonics: "Products—Vevo Integrated Rail System." <[http://www.visualsonics.com/products/products\\_rail.htm](http://www.visualsonics.com/products/products_rail.htm)>, accessed on Apr. 22, 2008; images published on Jan. 17, 2005, 4 pages.

\* cited by examiner



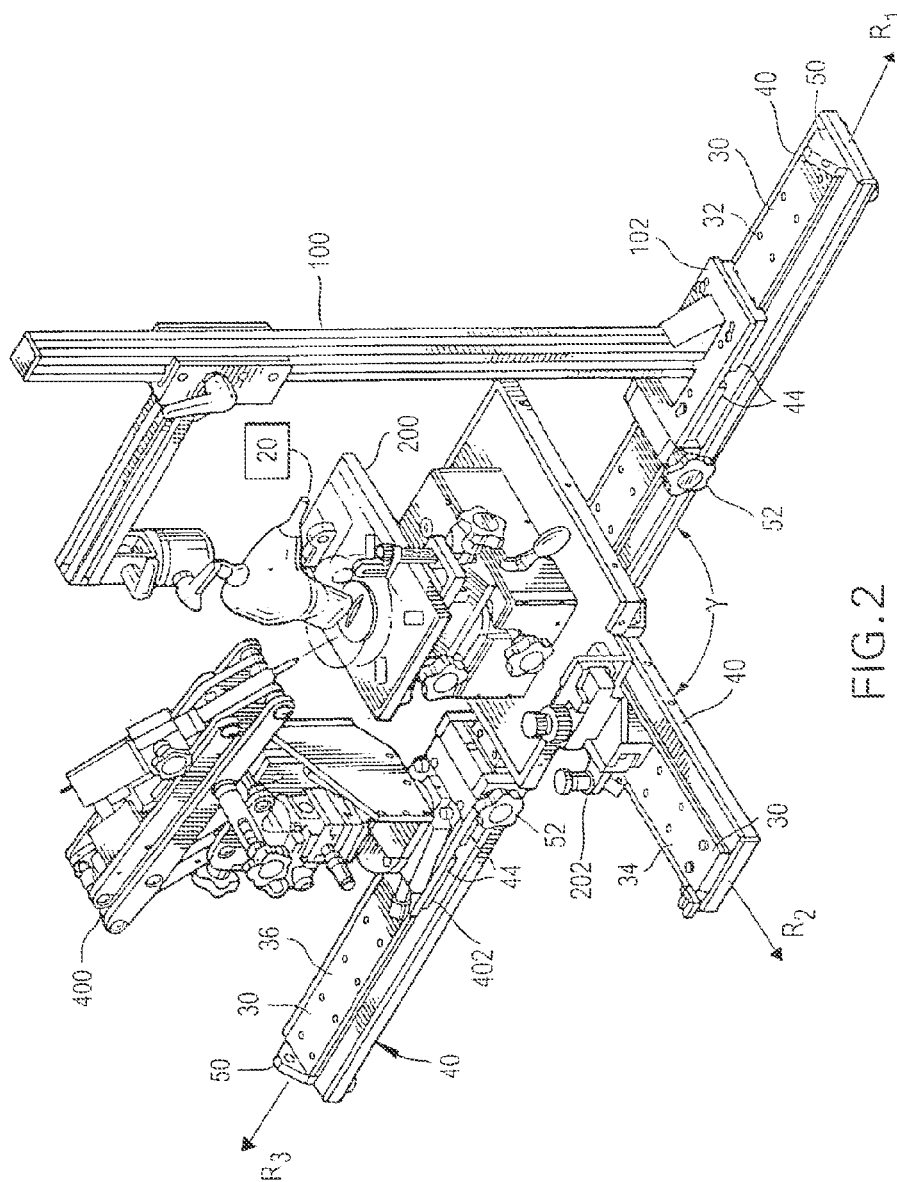
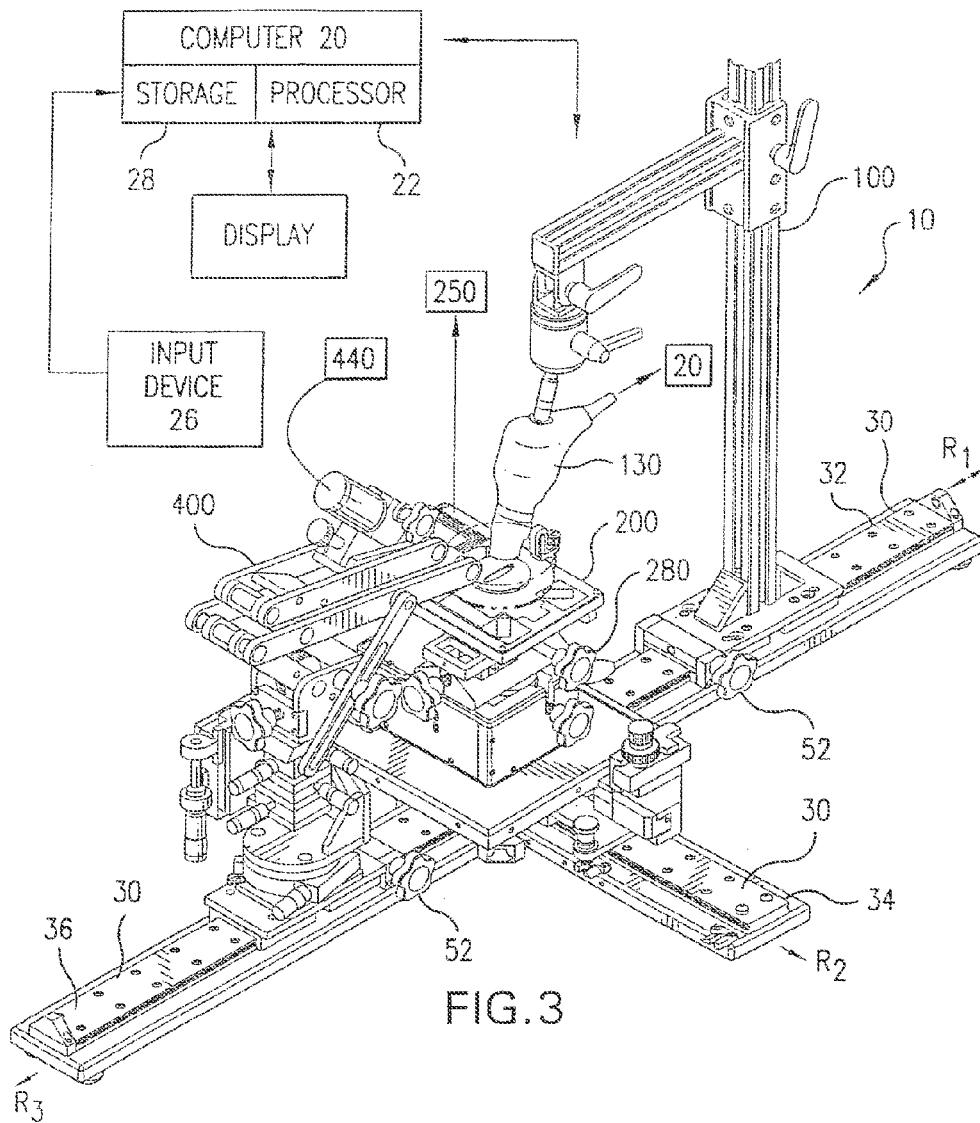


FIG. 2



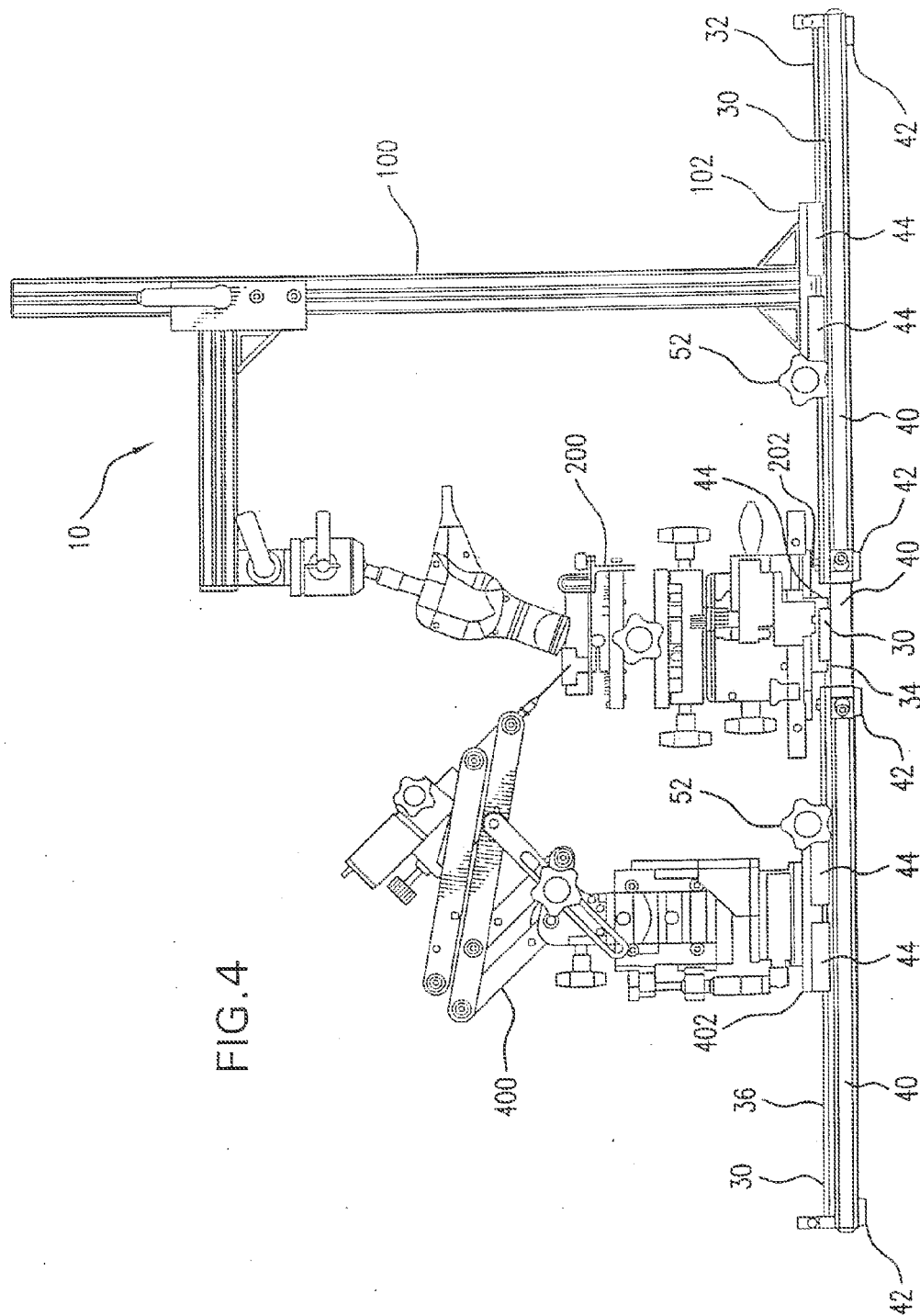
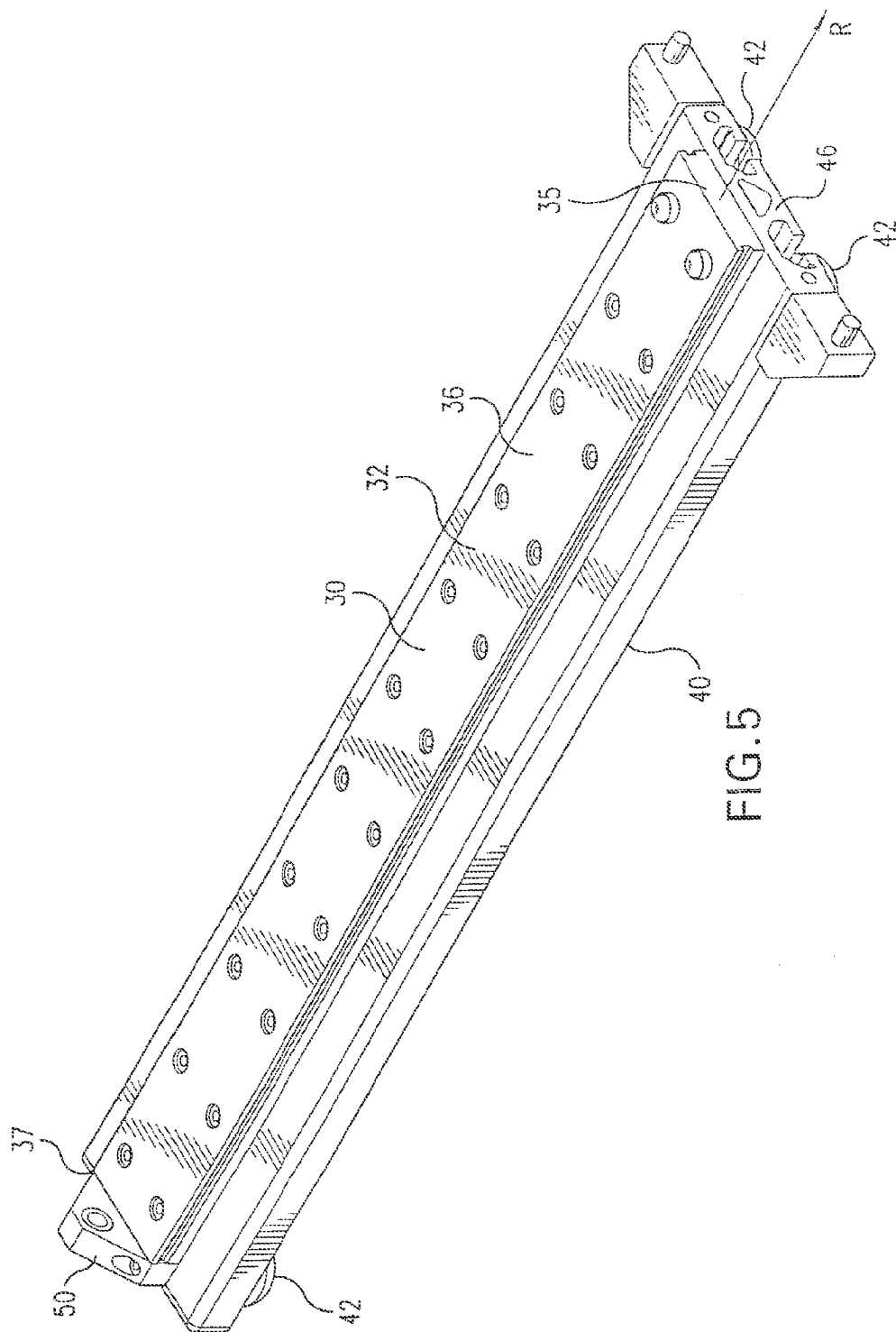
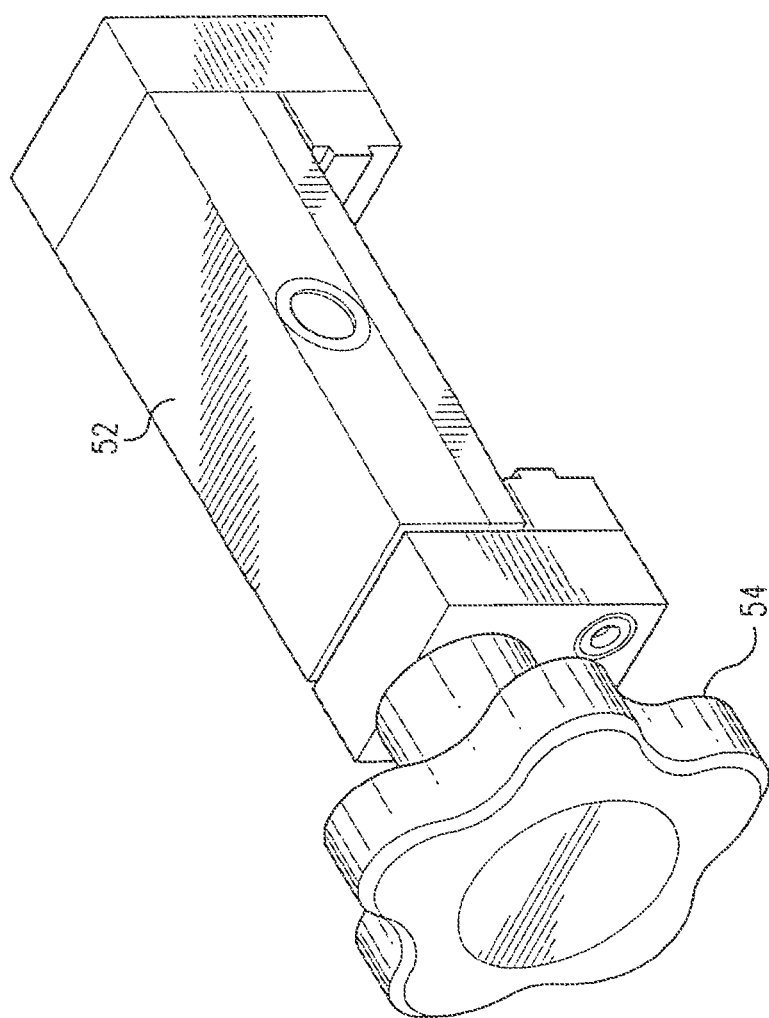


FIG. 4







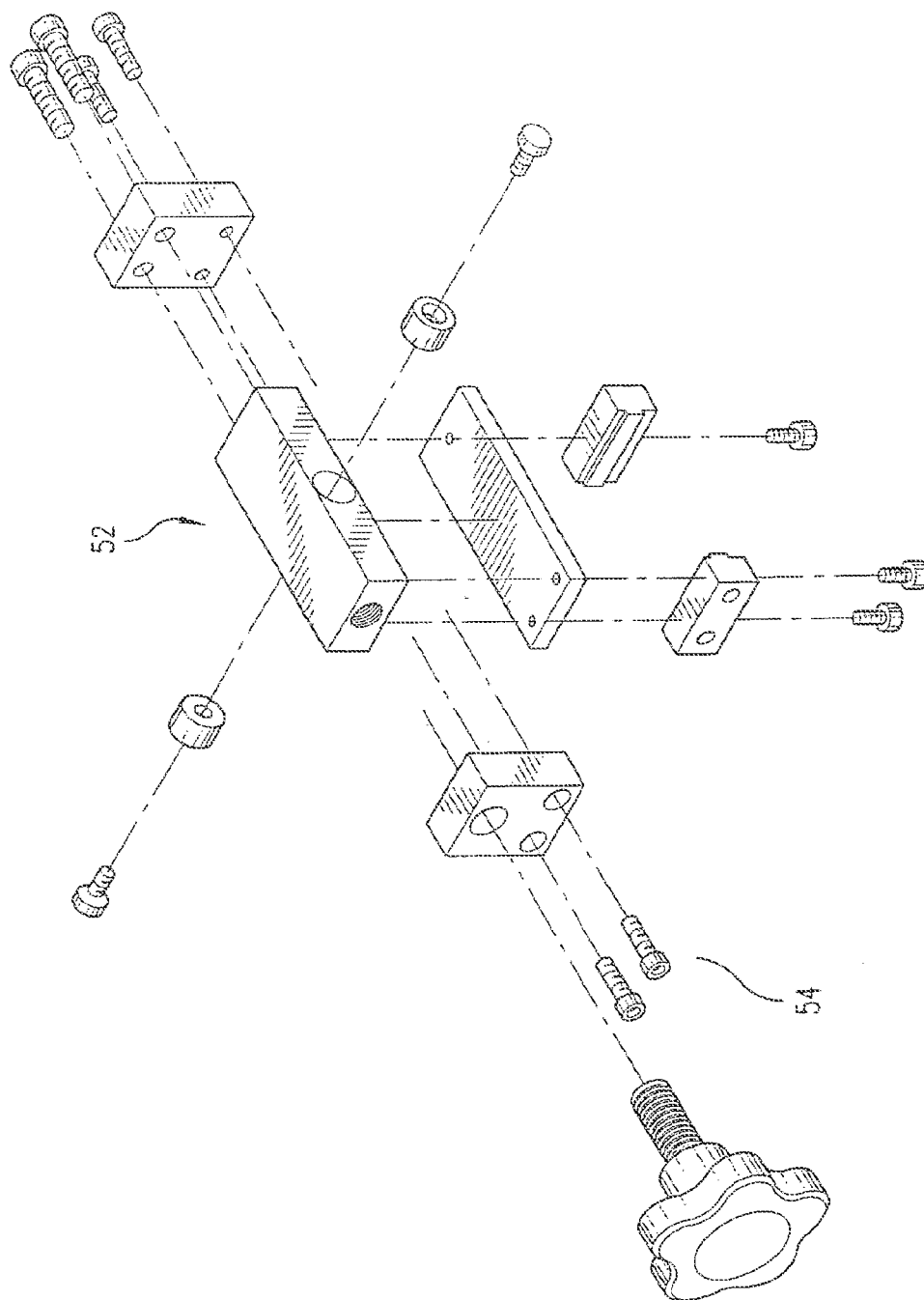
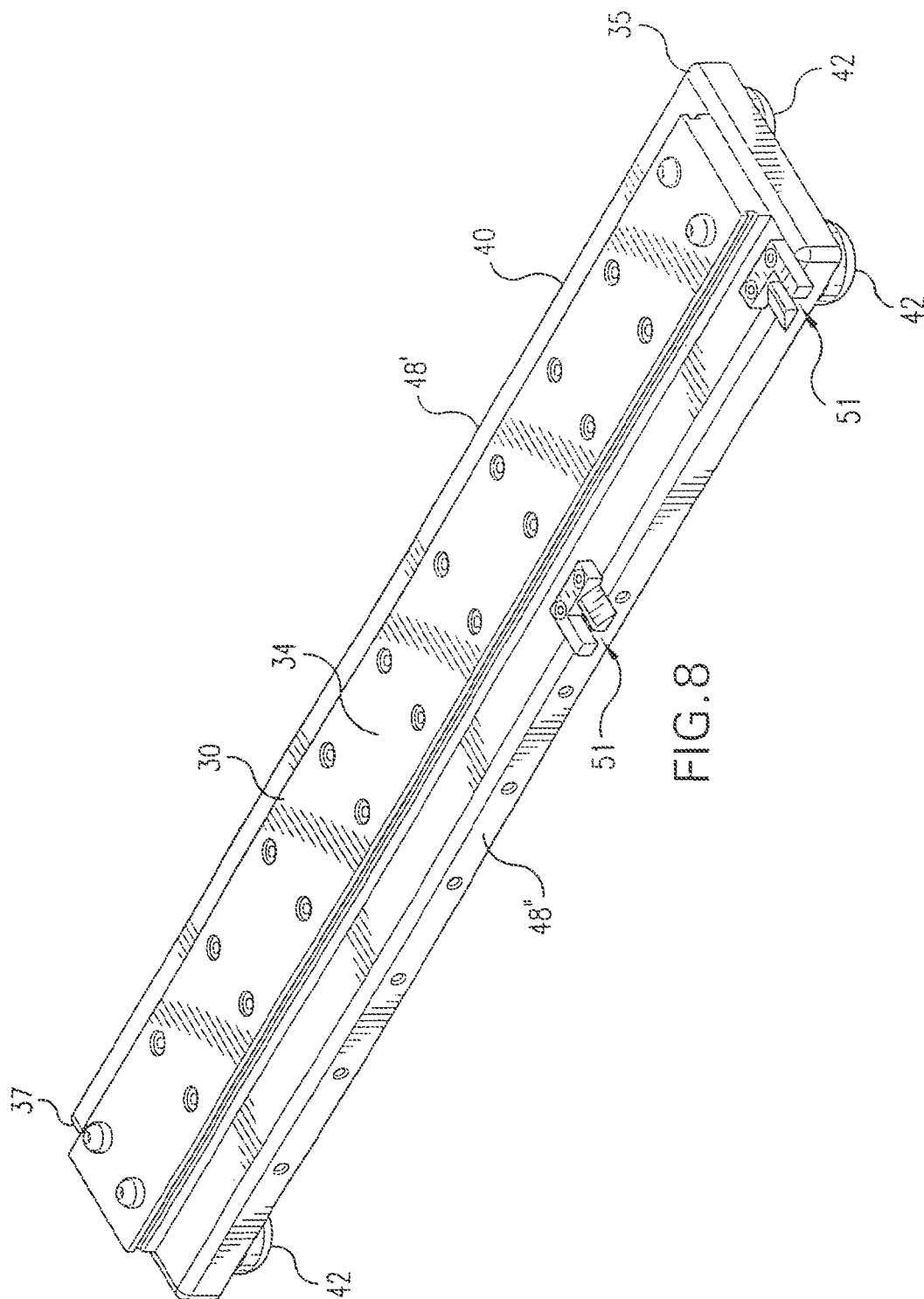
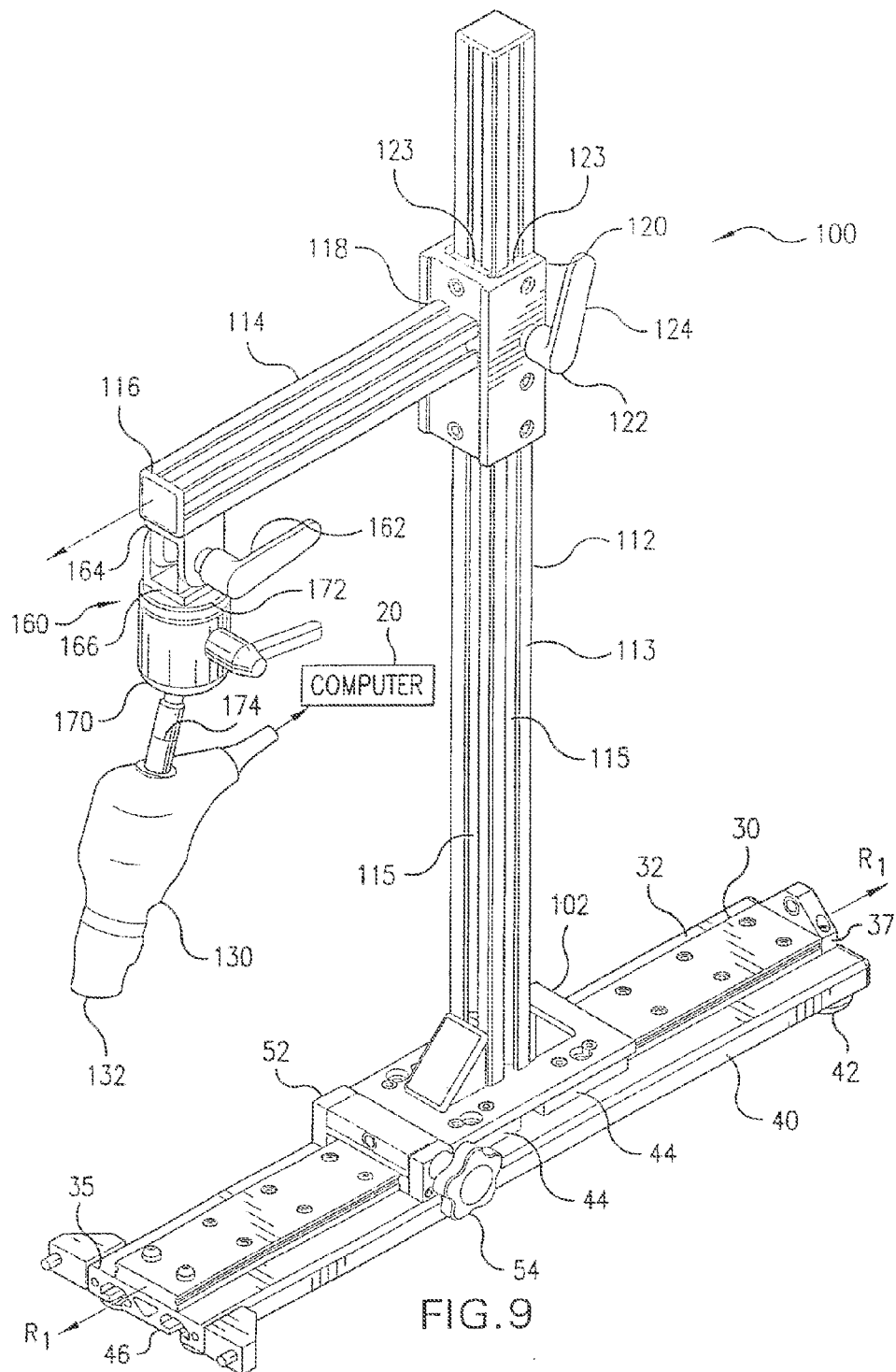
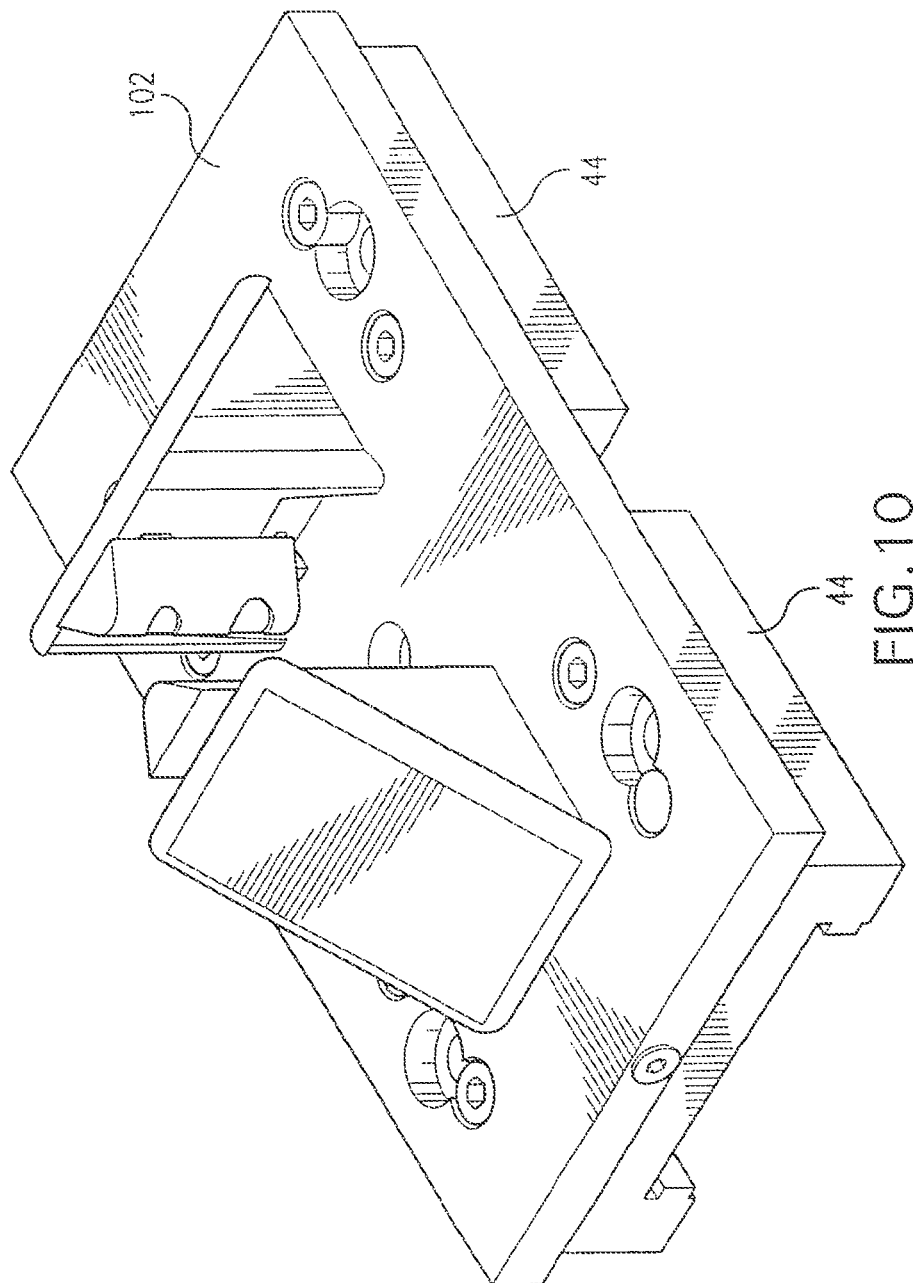


FIG. 7







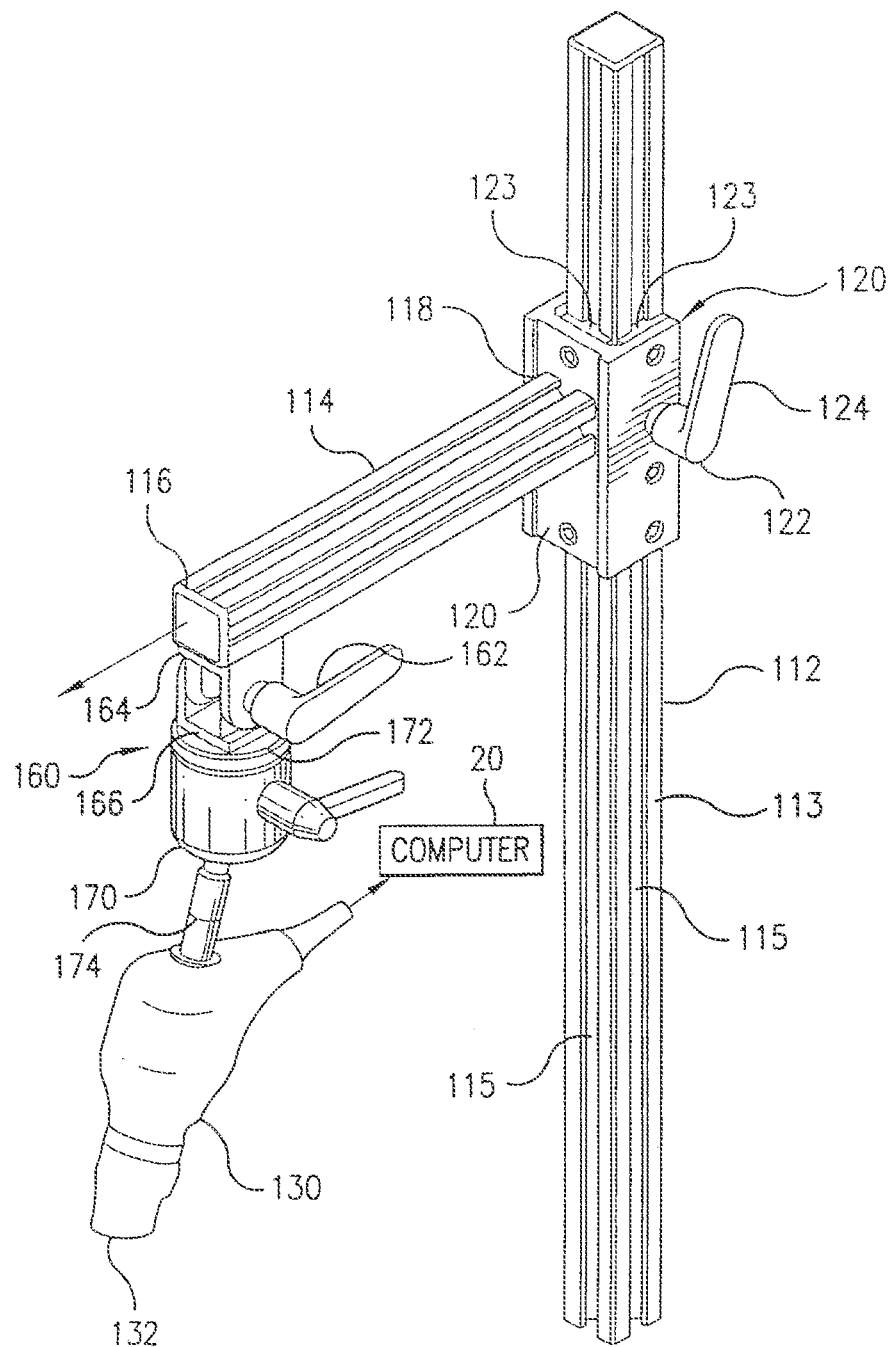
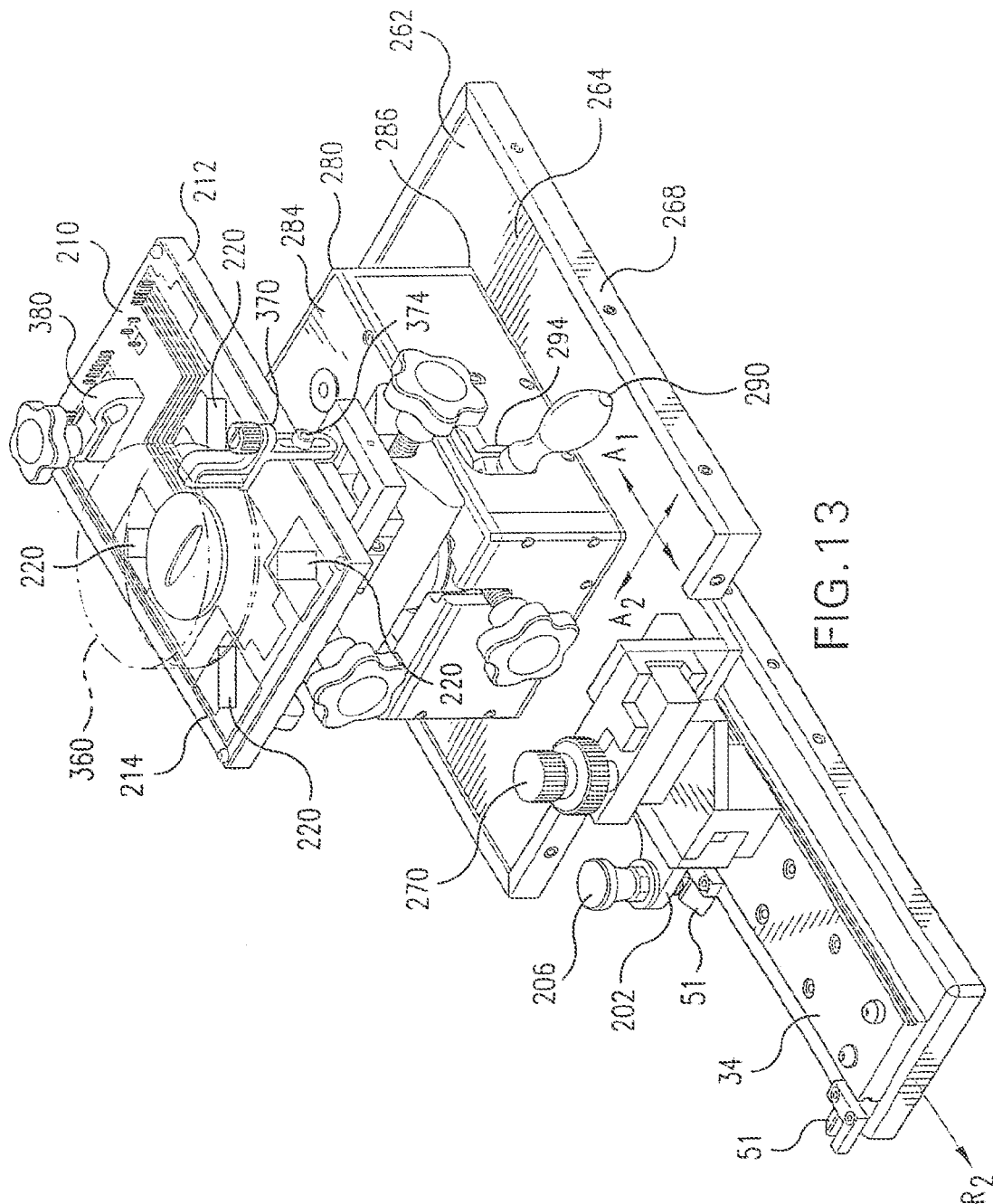
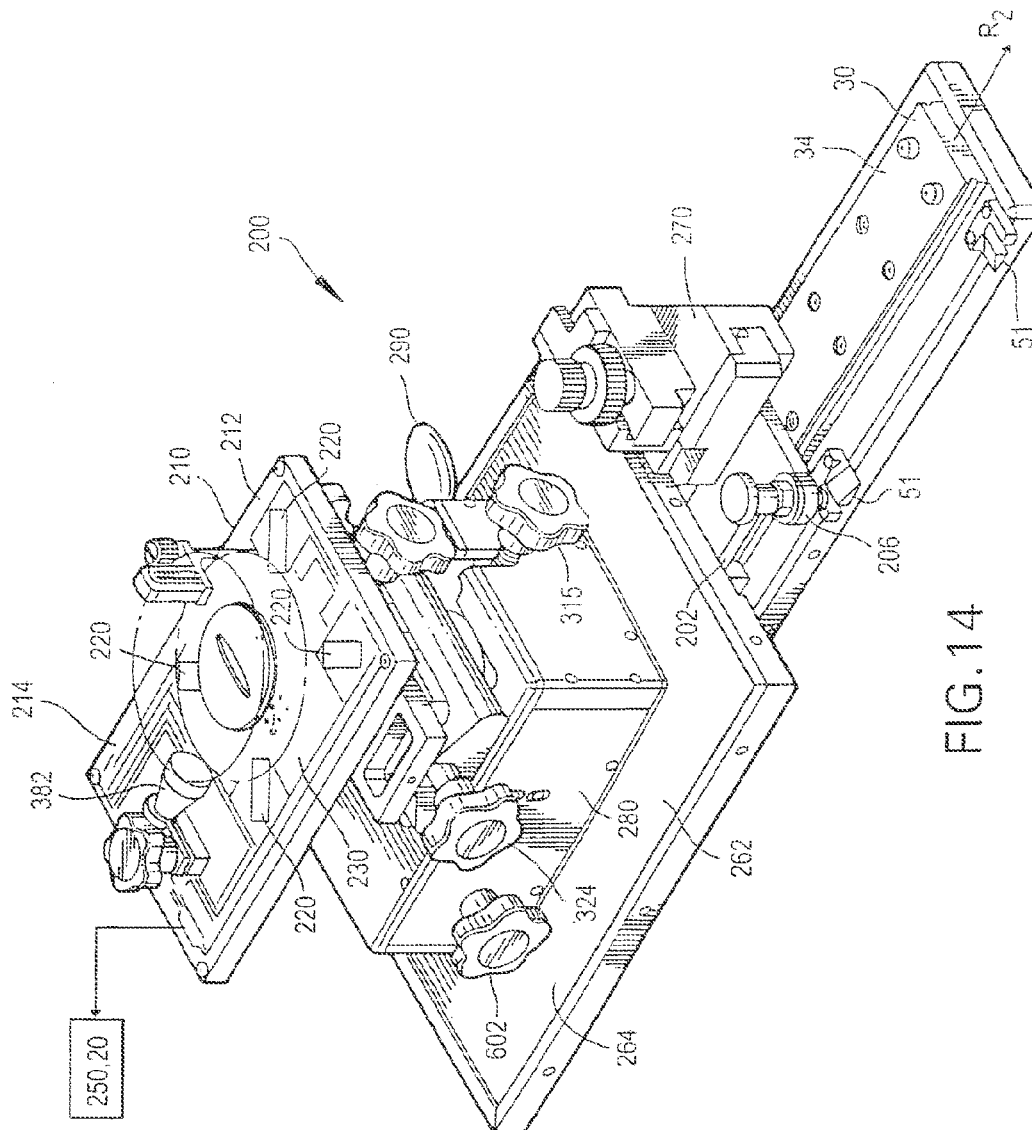


FIG 11









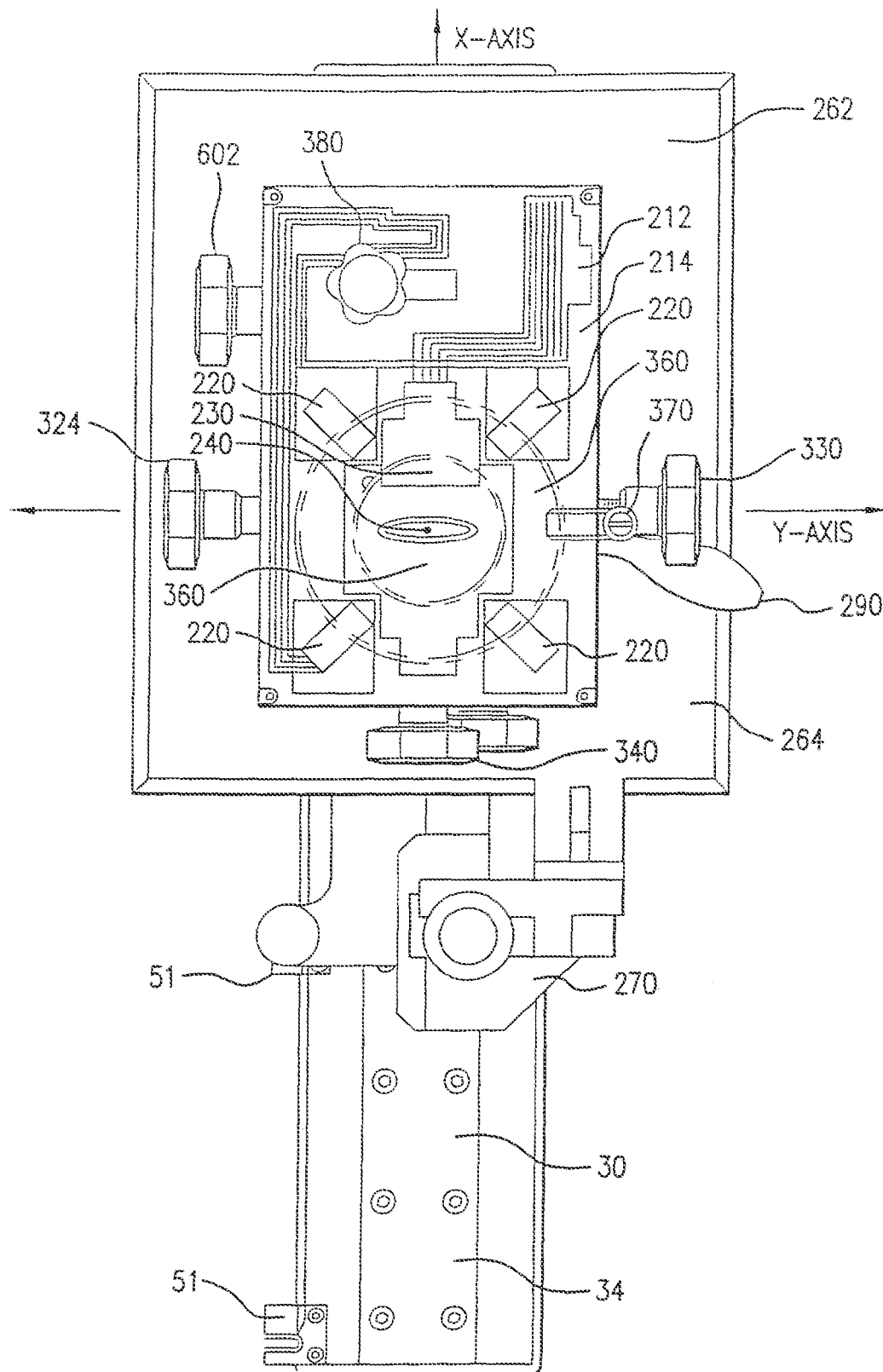


FIG. 15

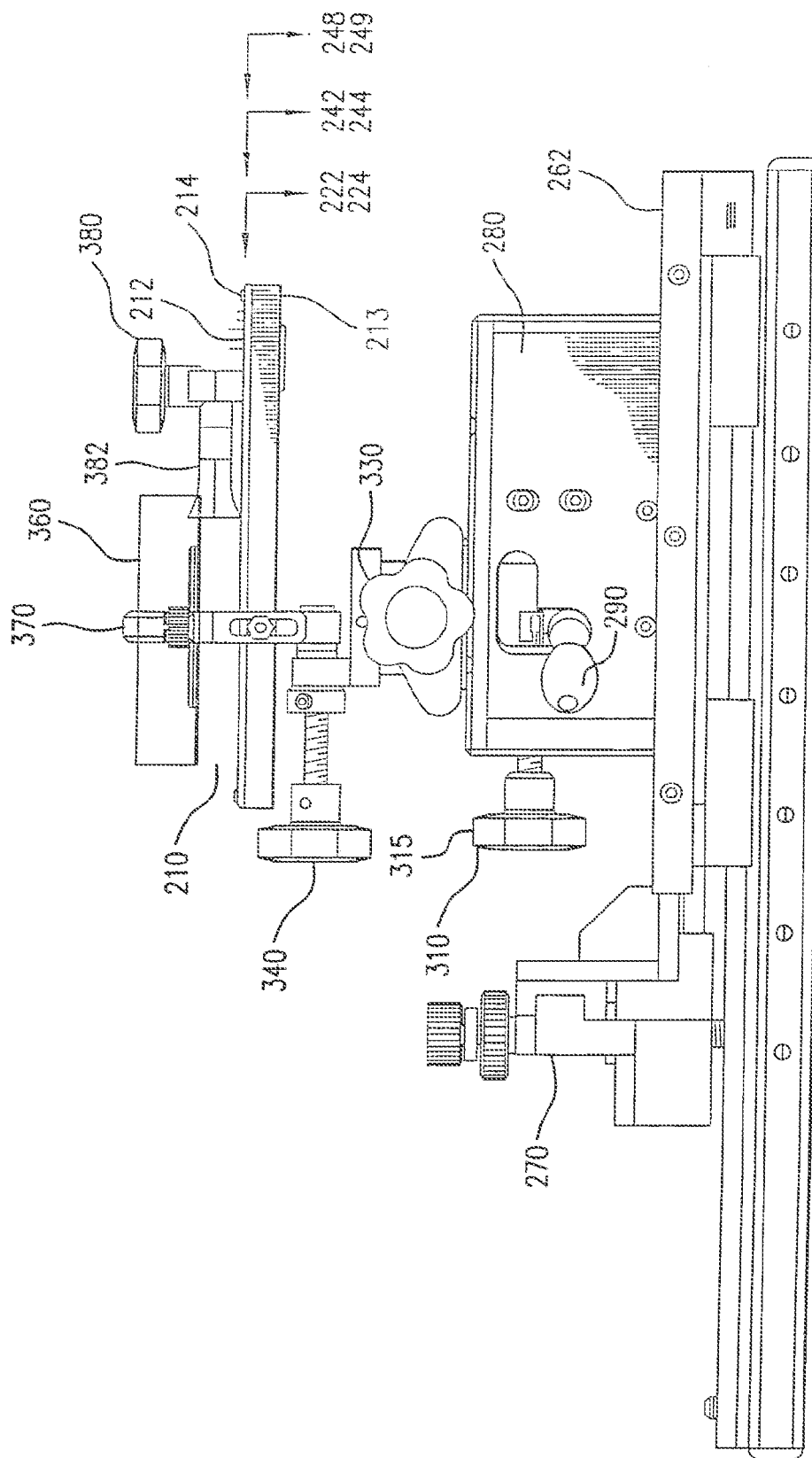
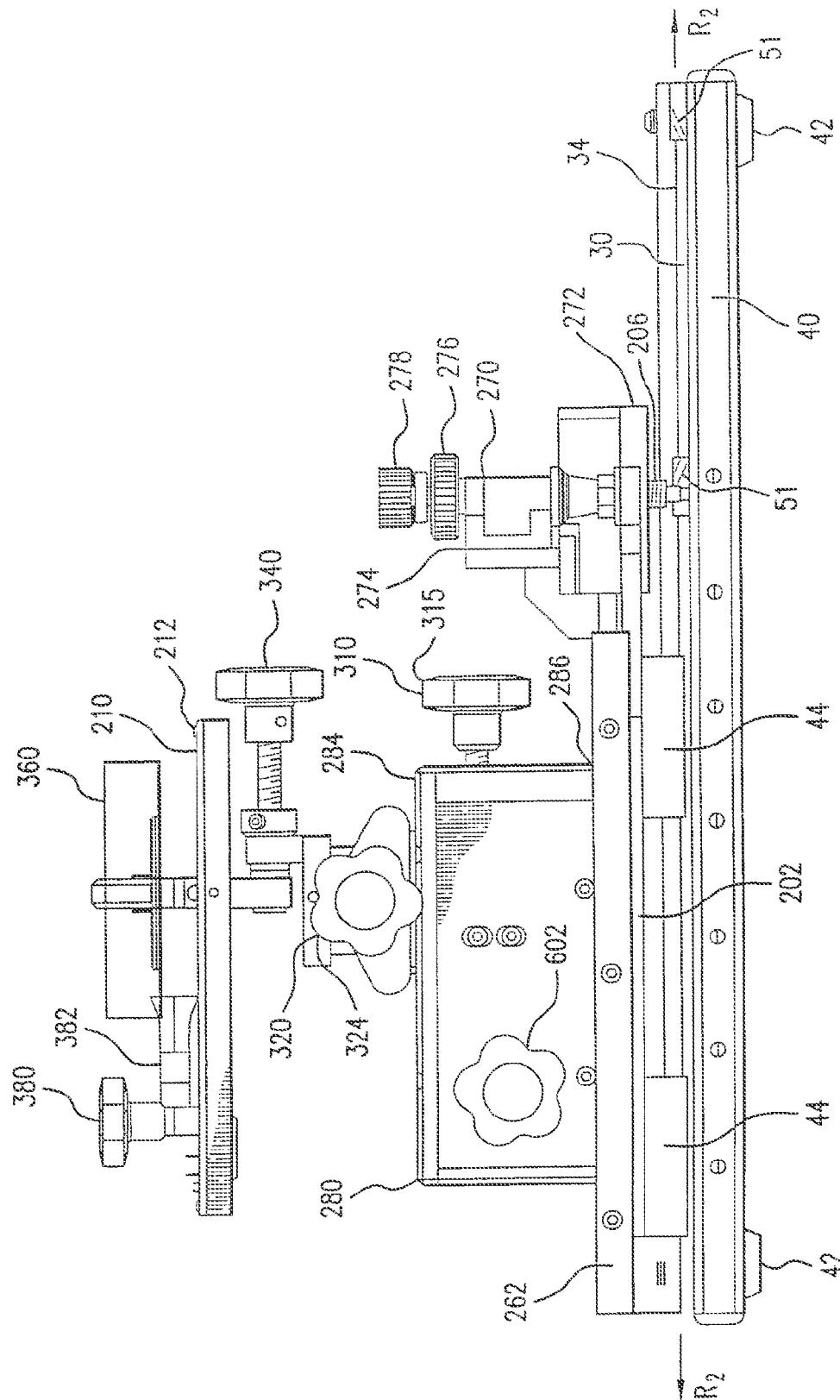
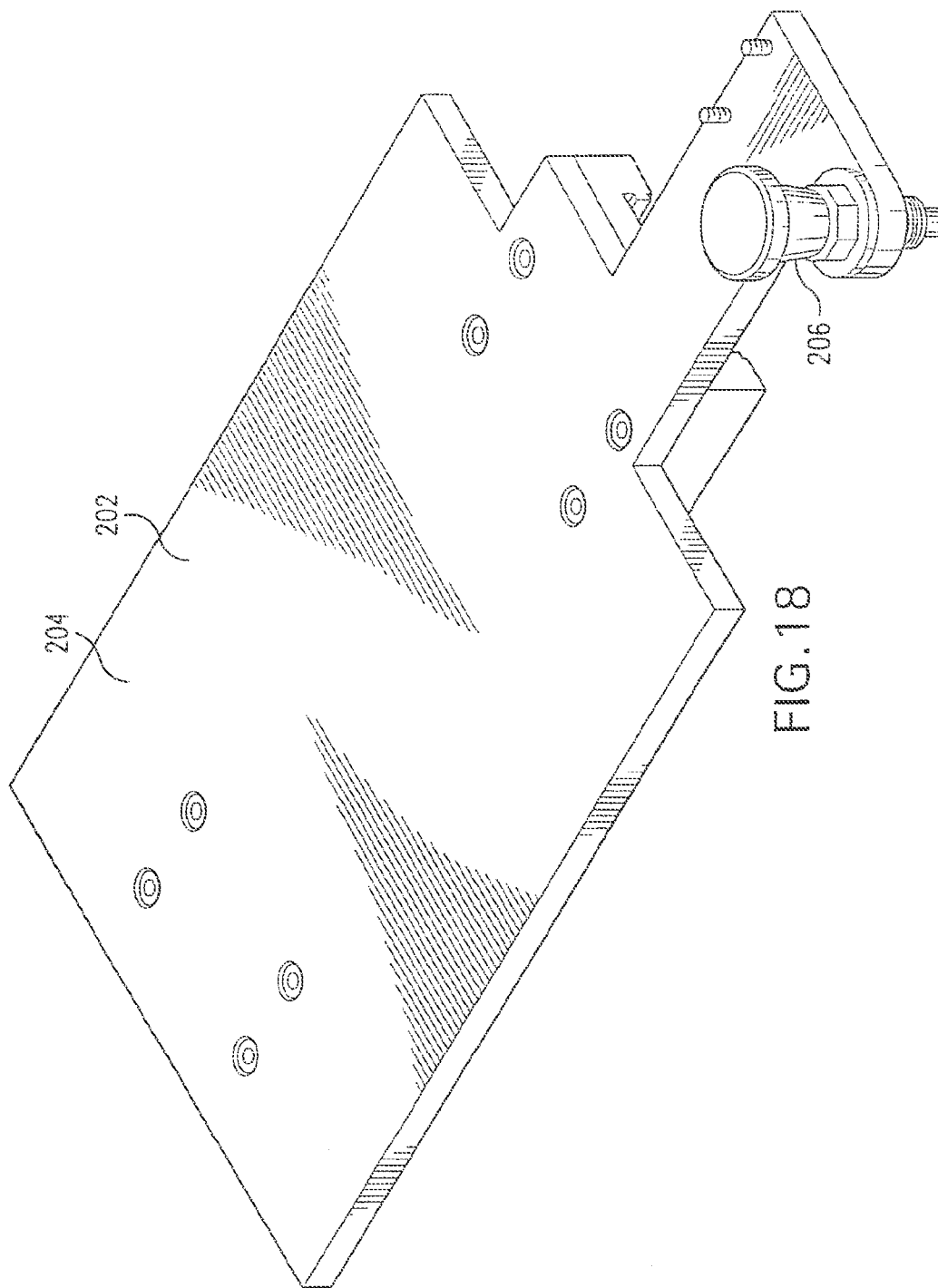


FIG. 16



7.1 GIL



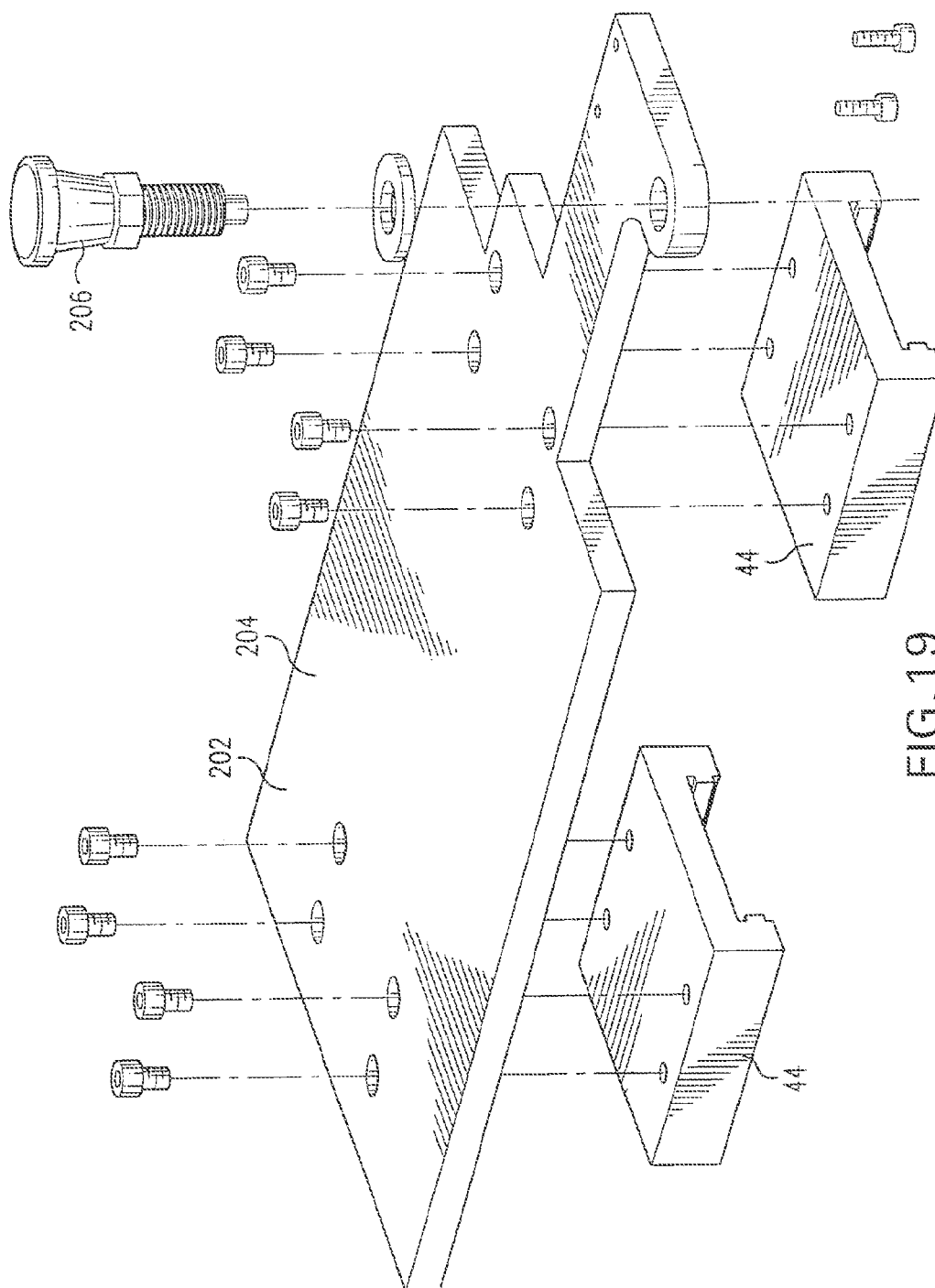


FIG. 19

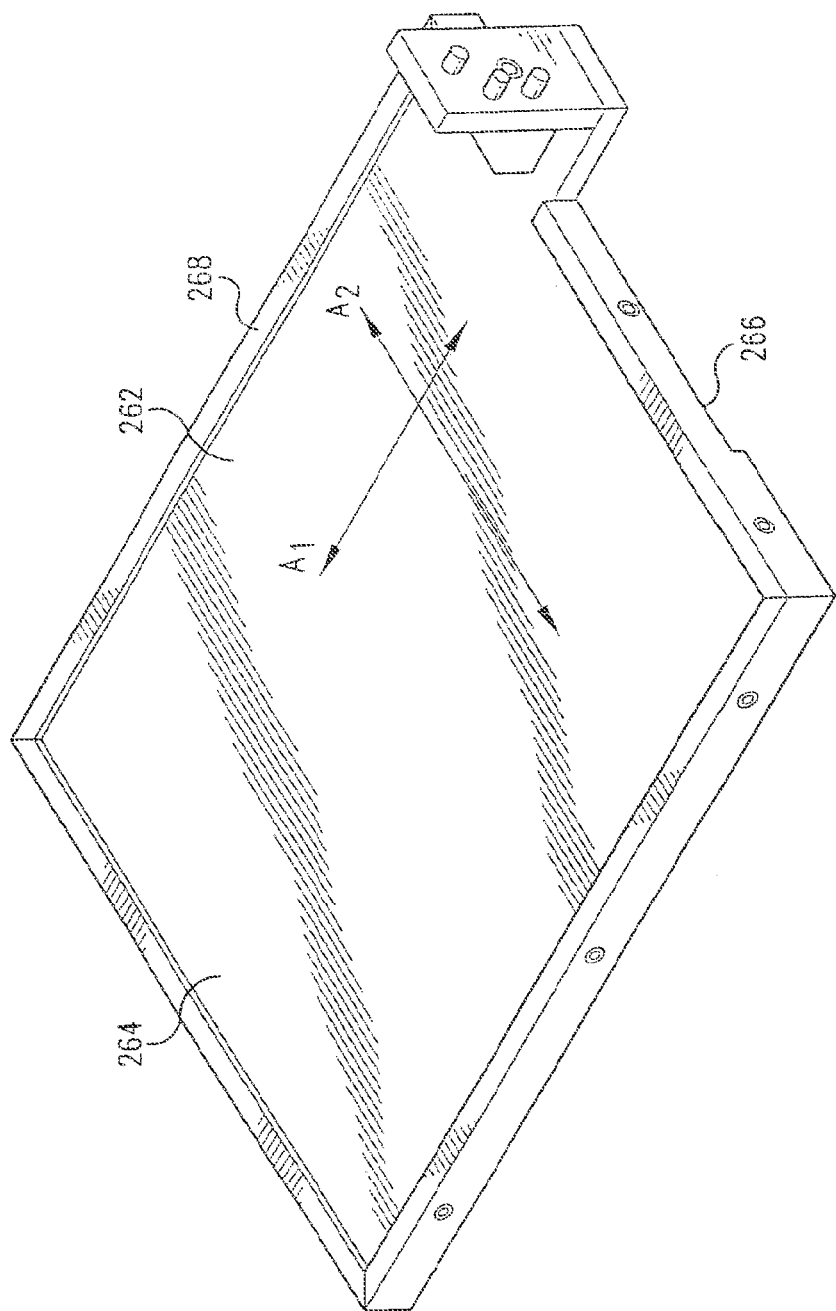
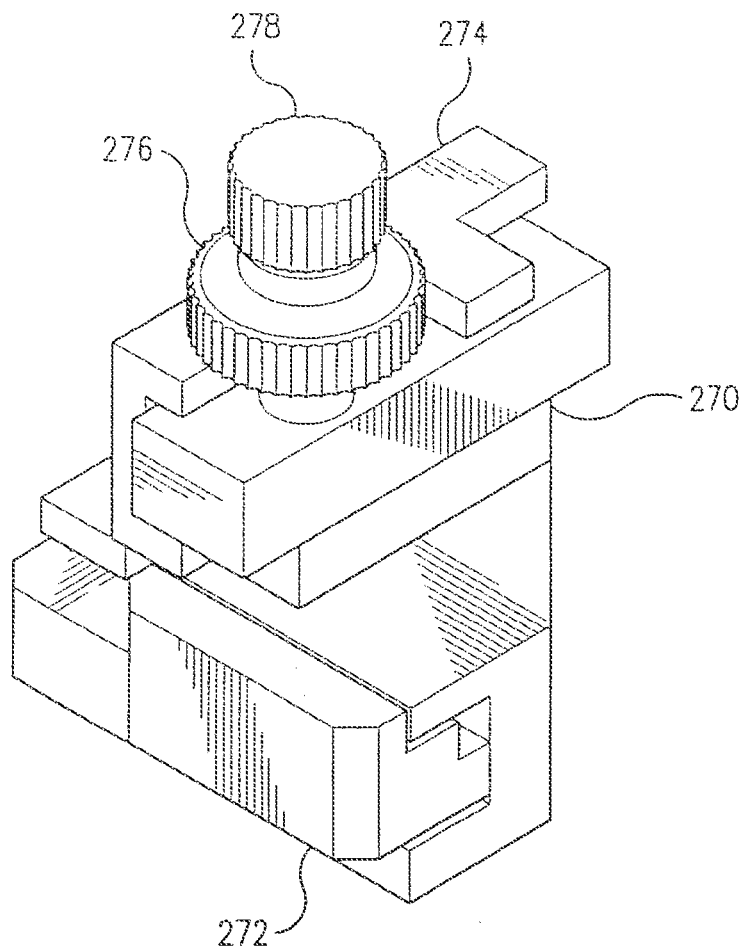


FIG. 20



272  
FIG. 21

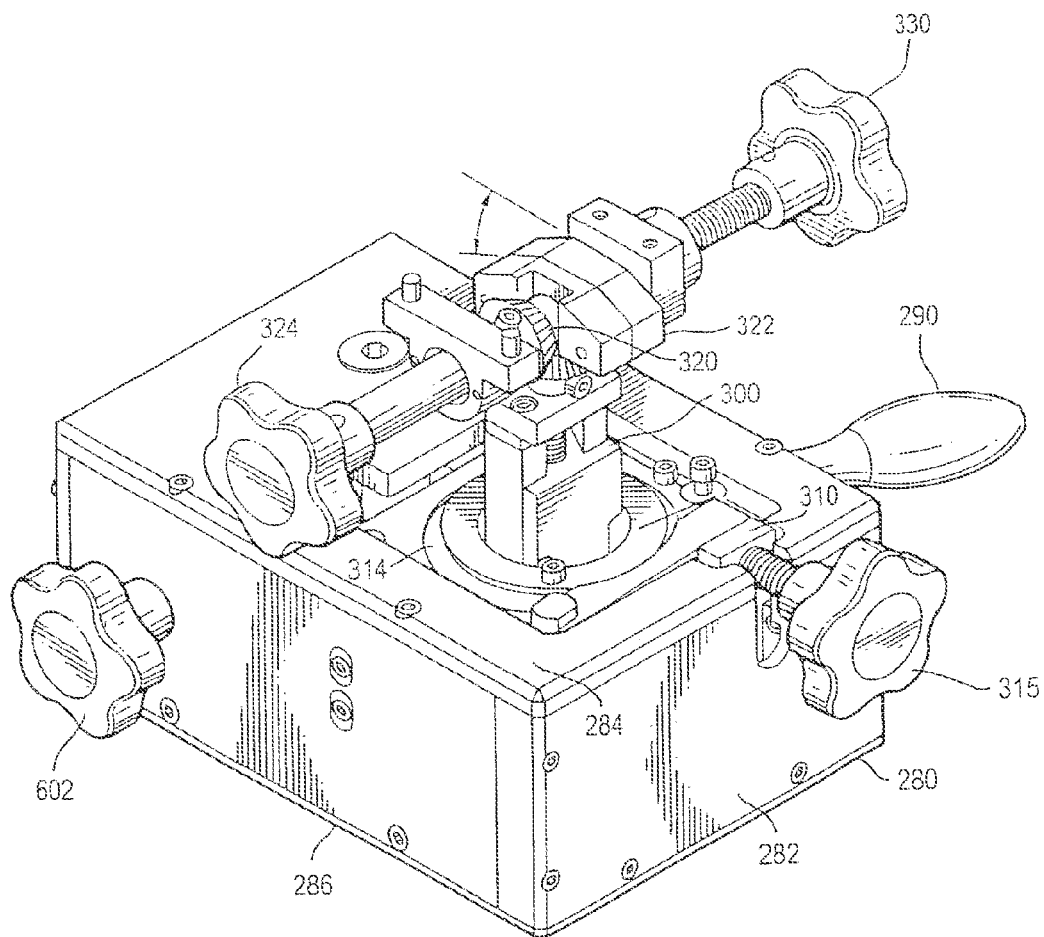
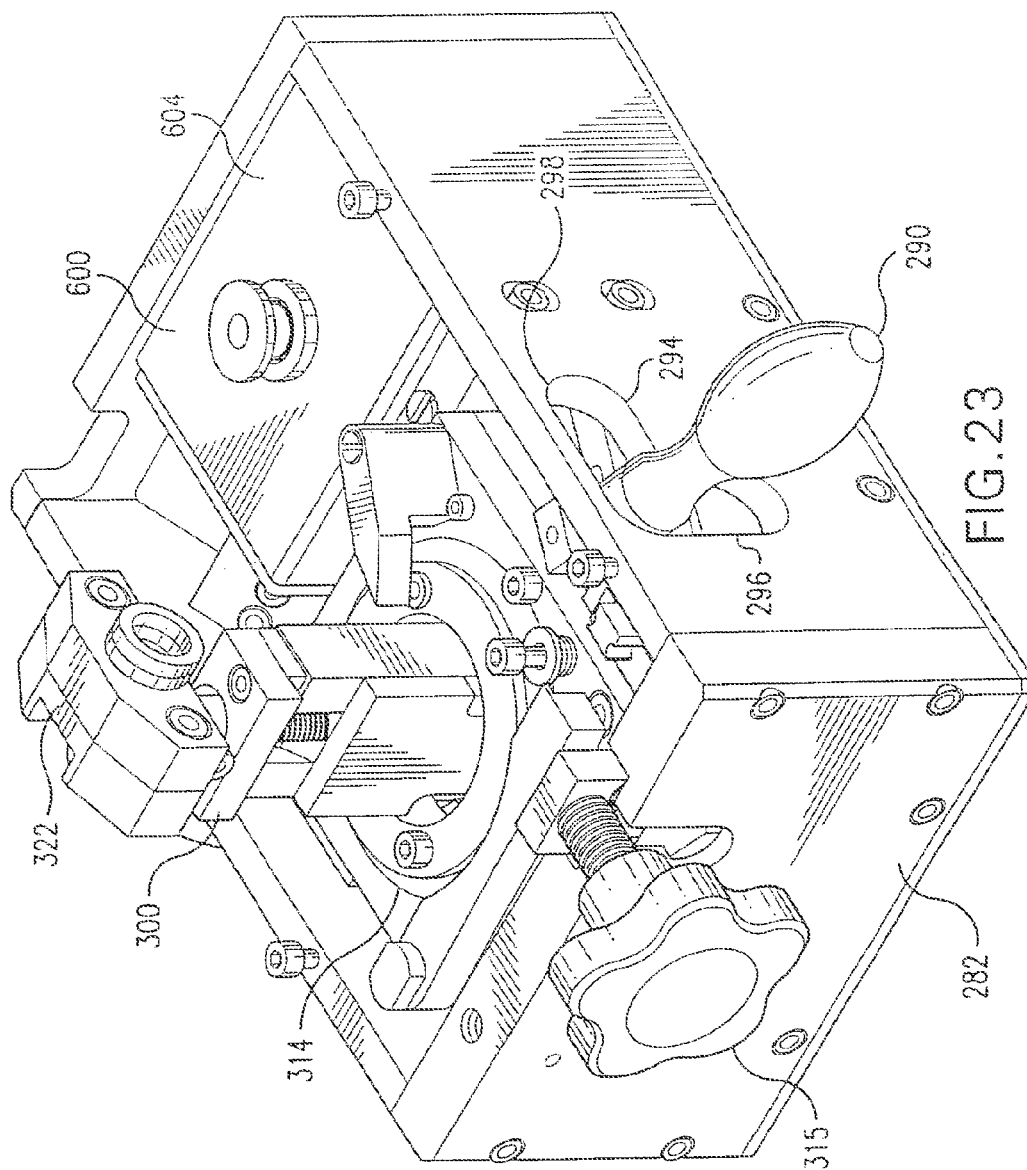


FIG. 22





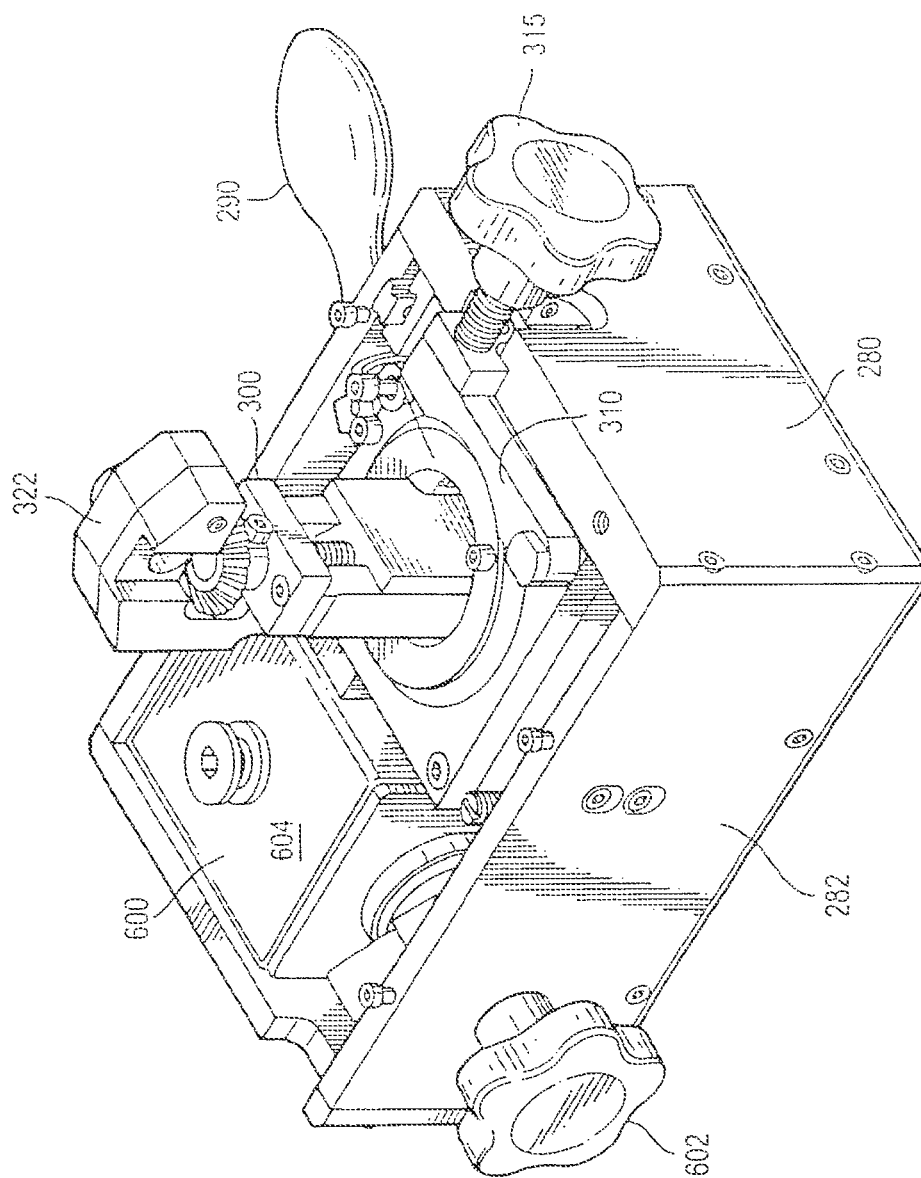


FIG. 24

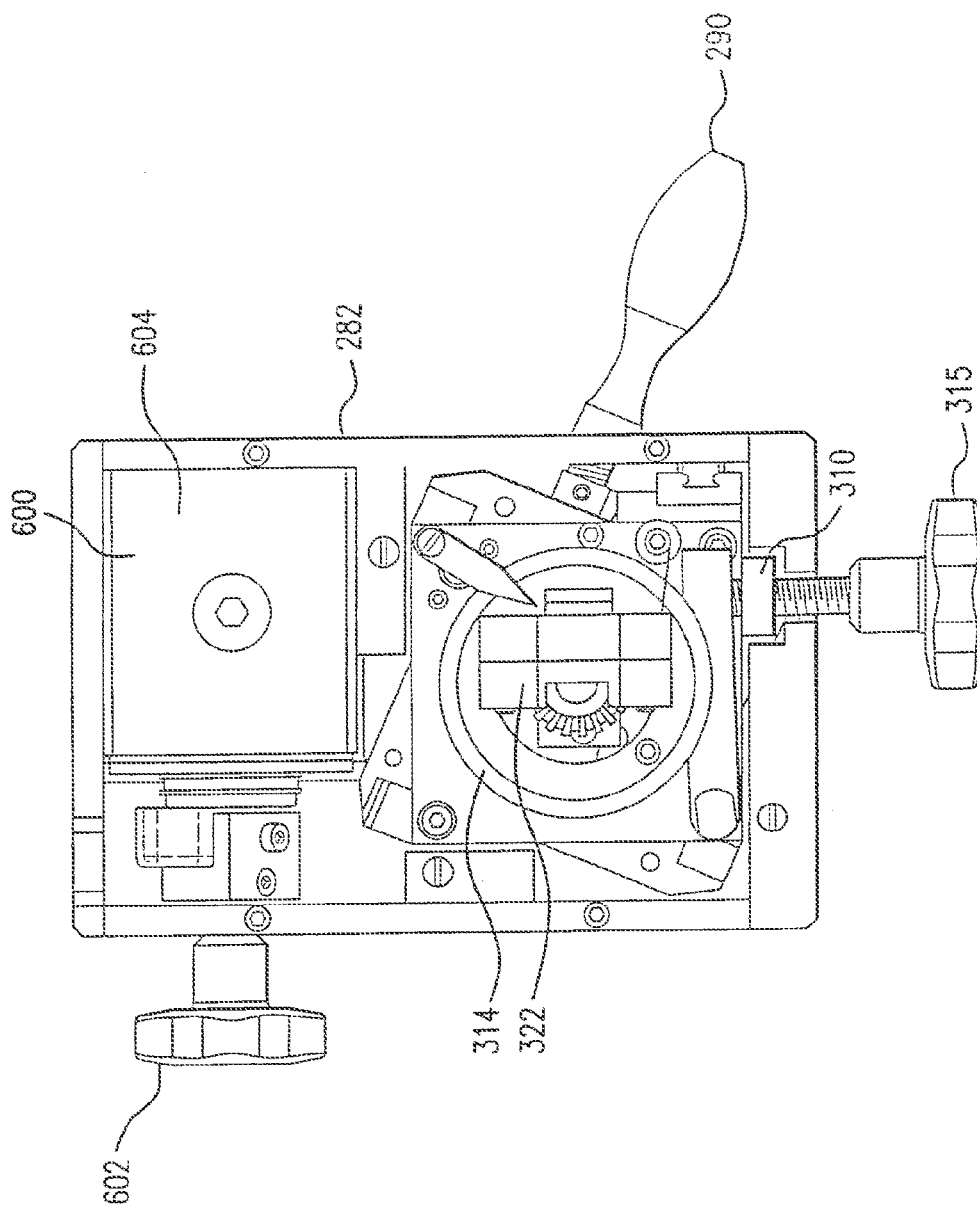


FIG. 25

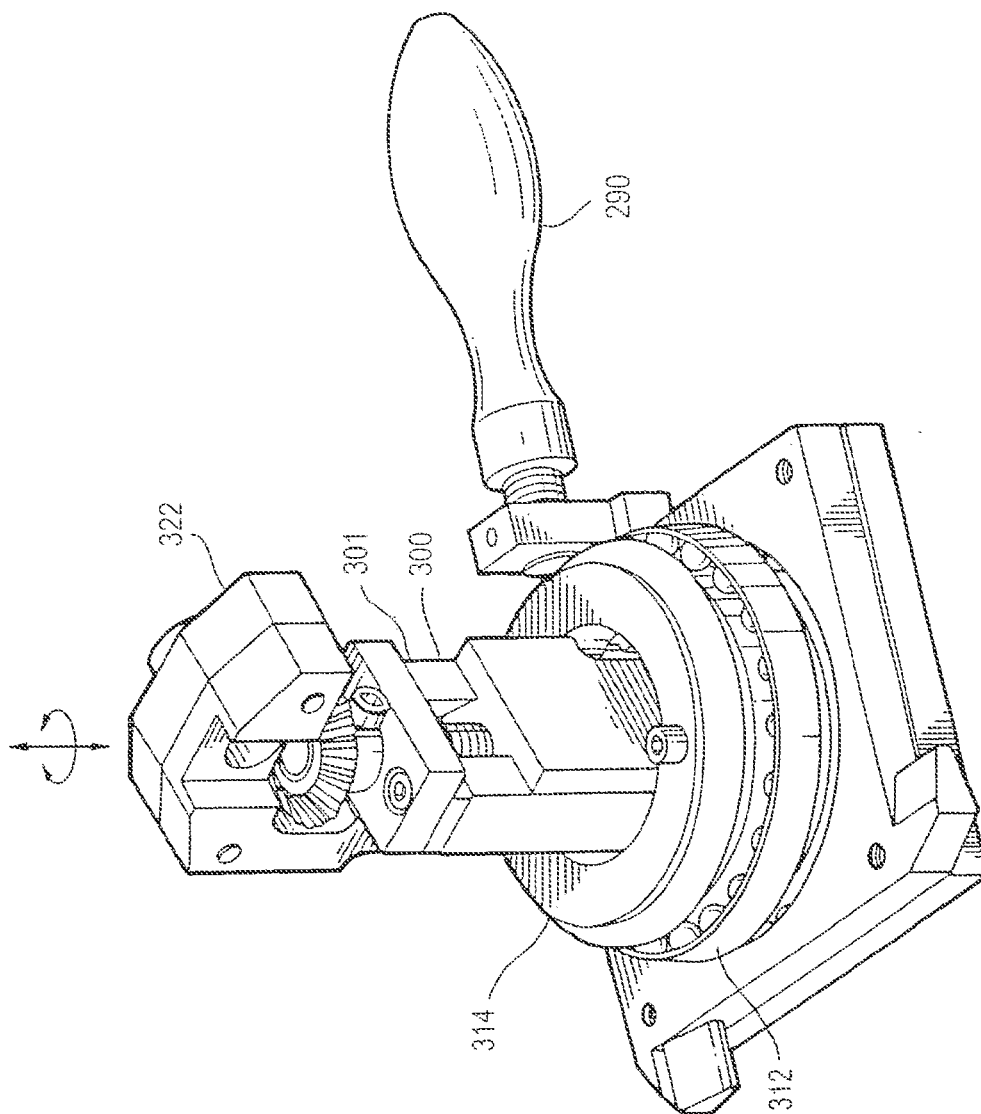


FIG. 26

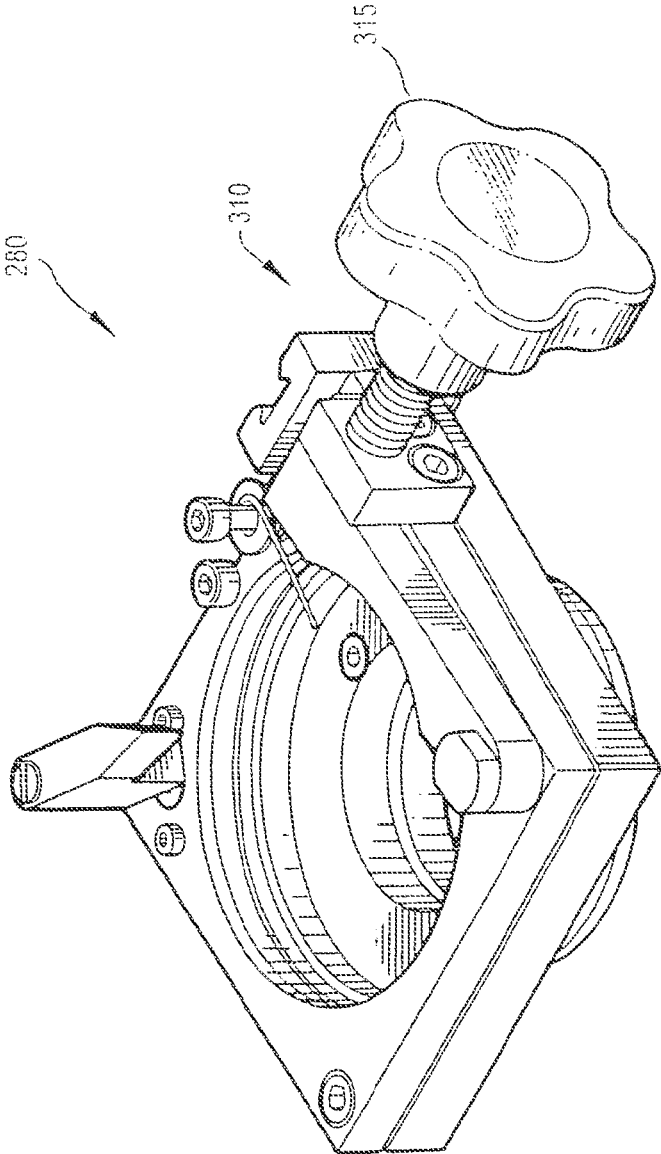


FIG. 27

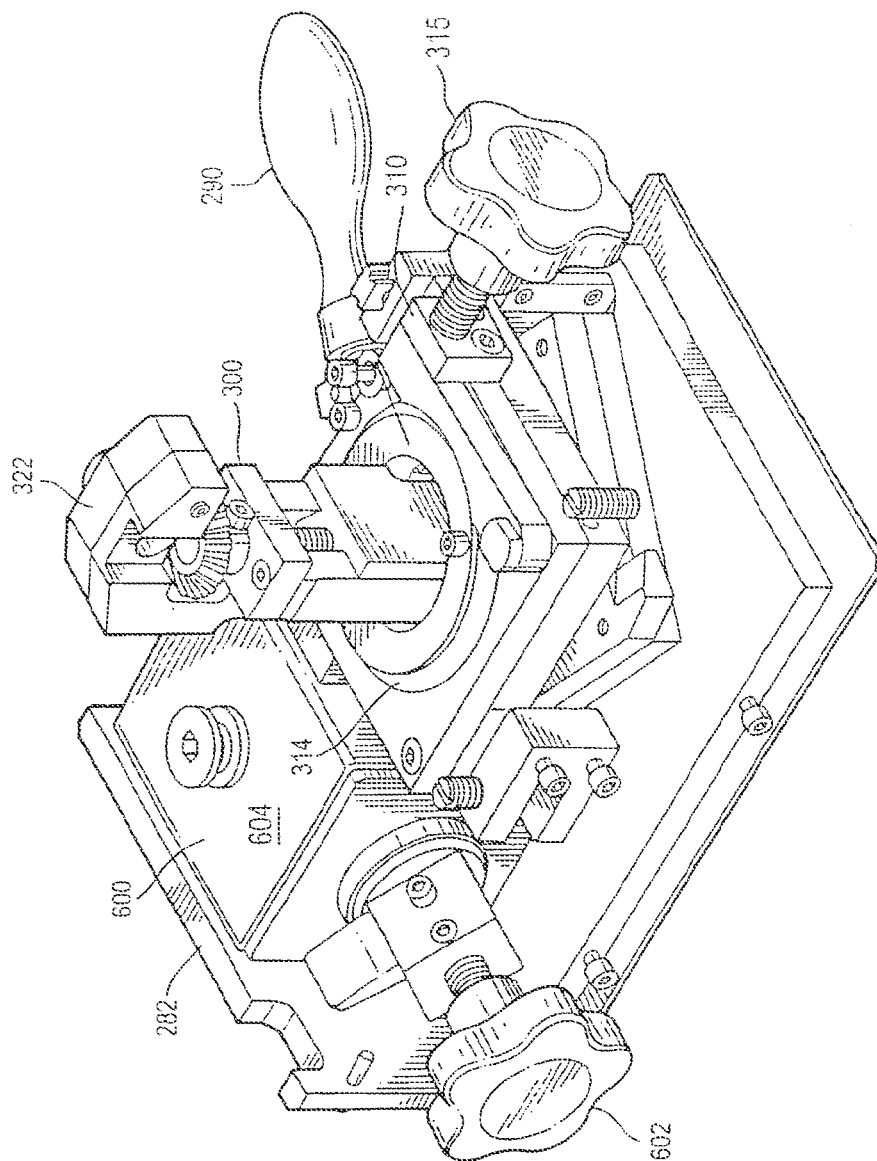


FIG. 28

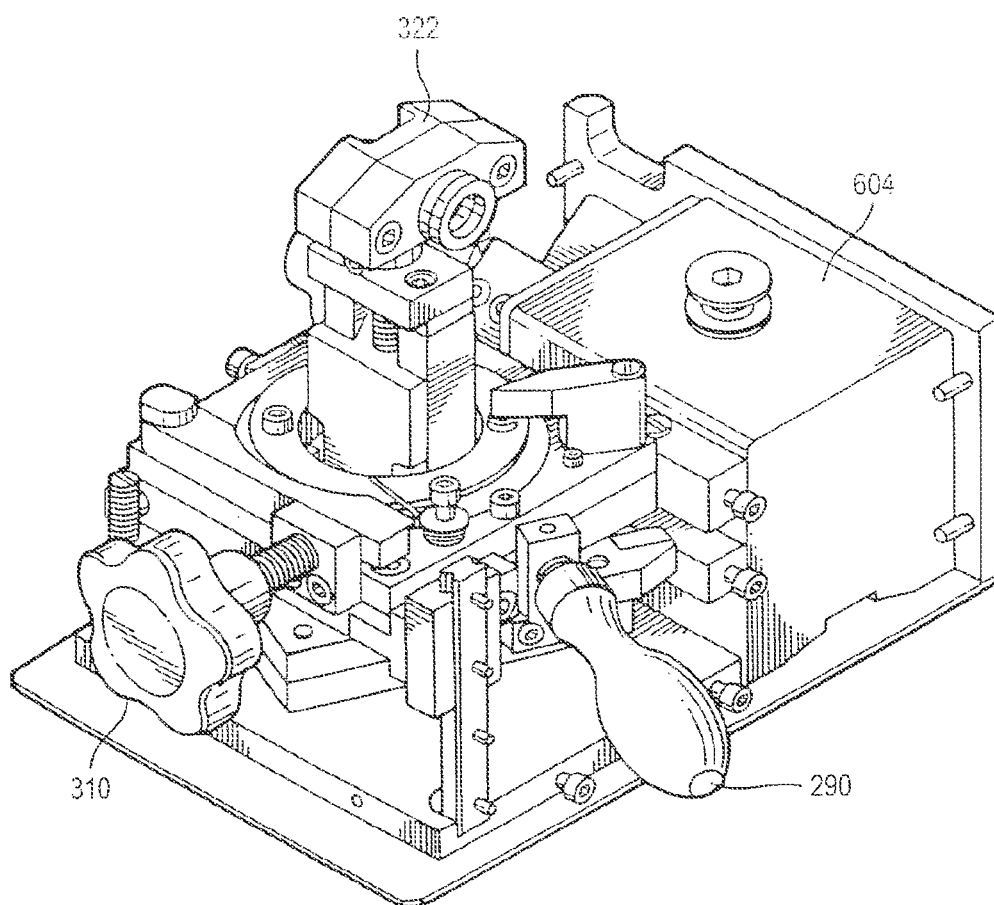
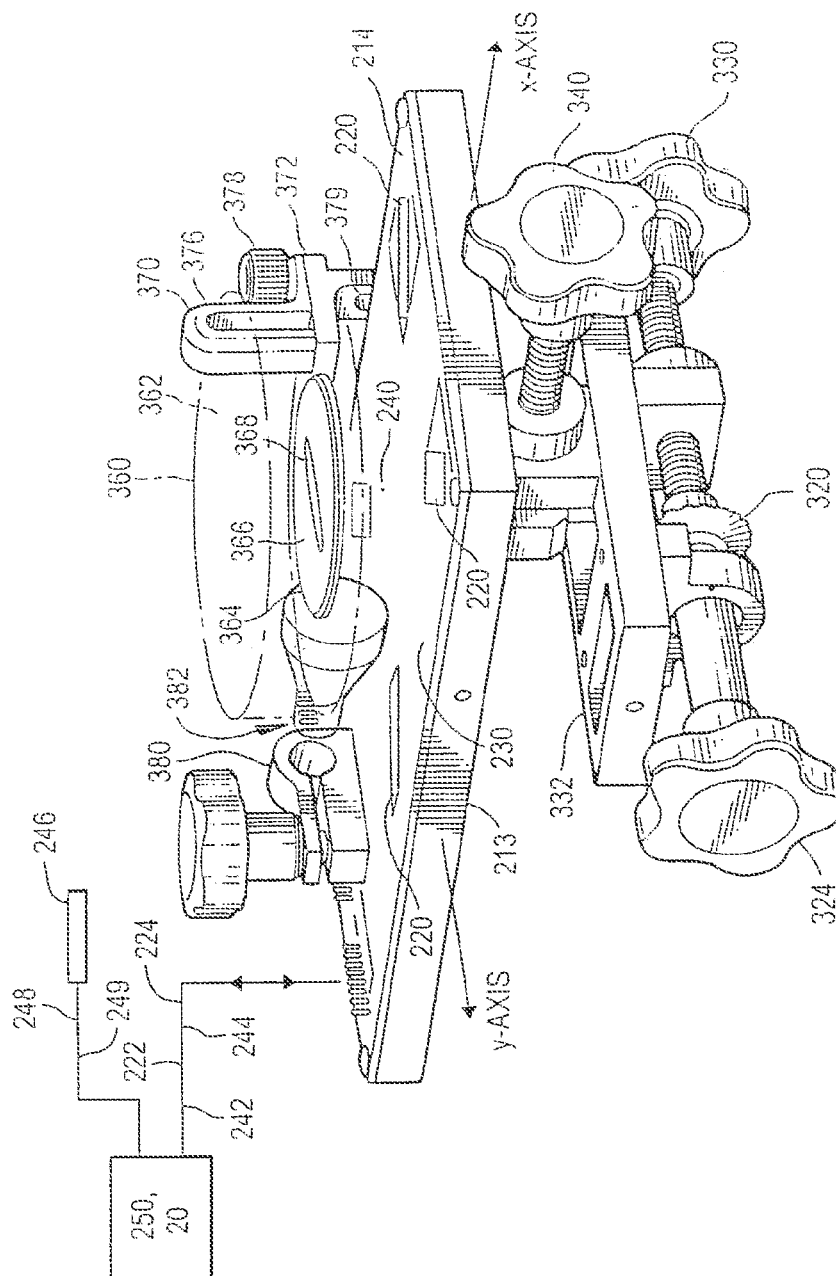


FIG. 29



OMG!!!



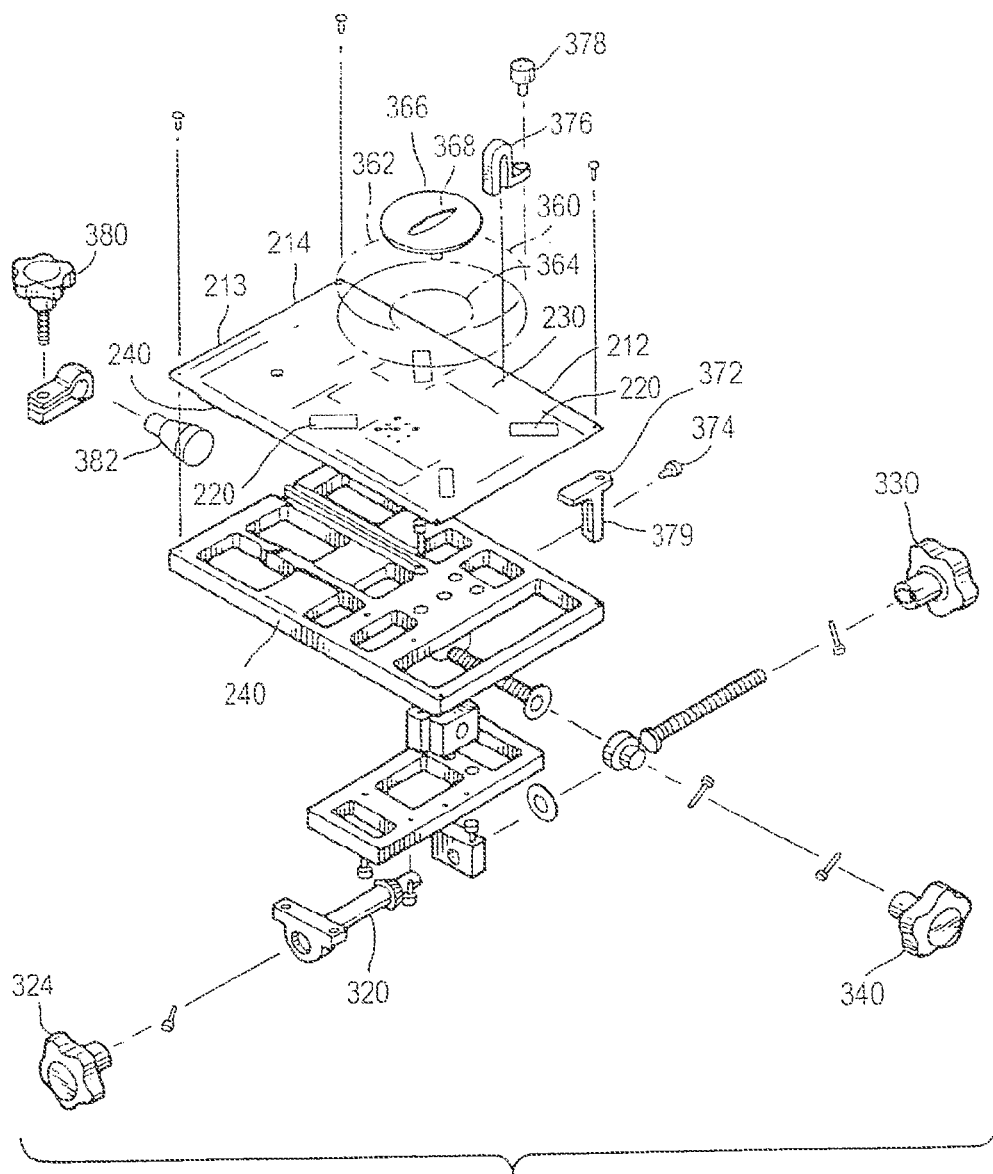
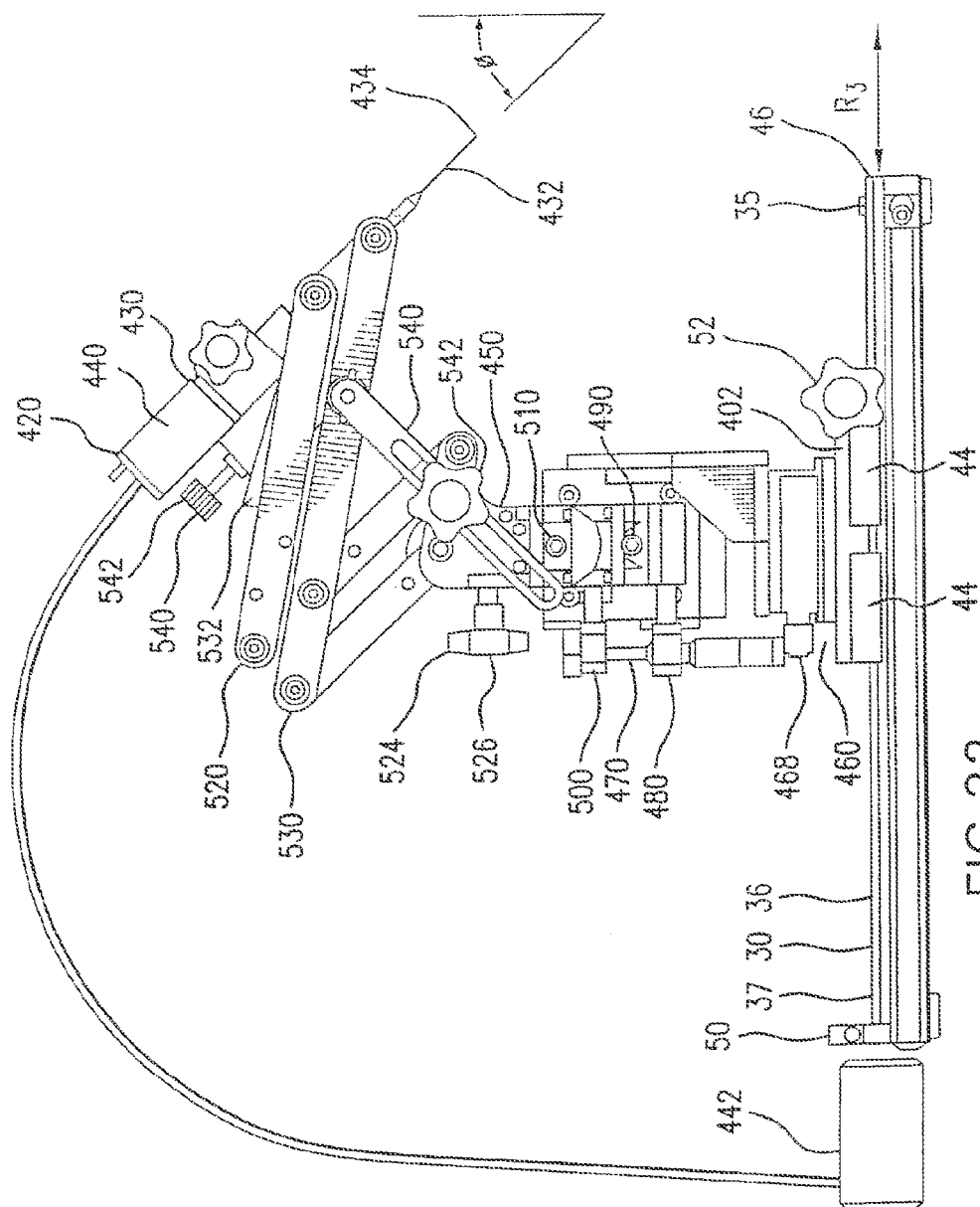


FIG. 31





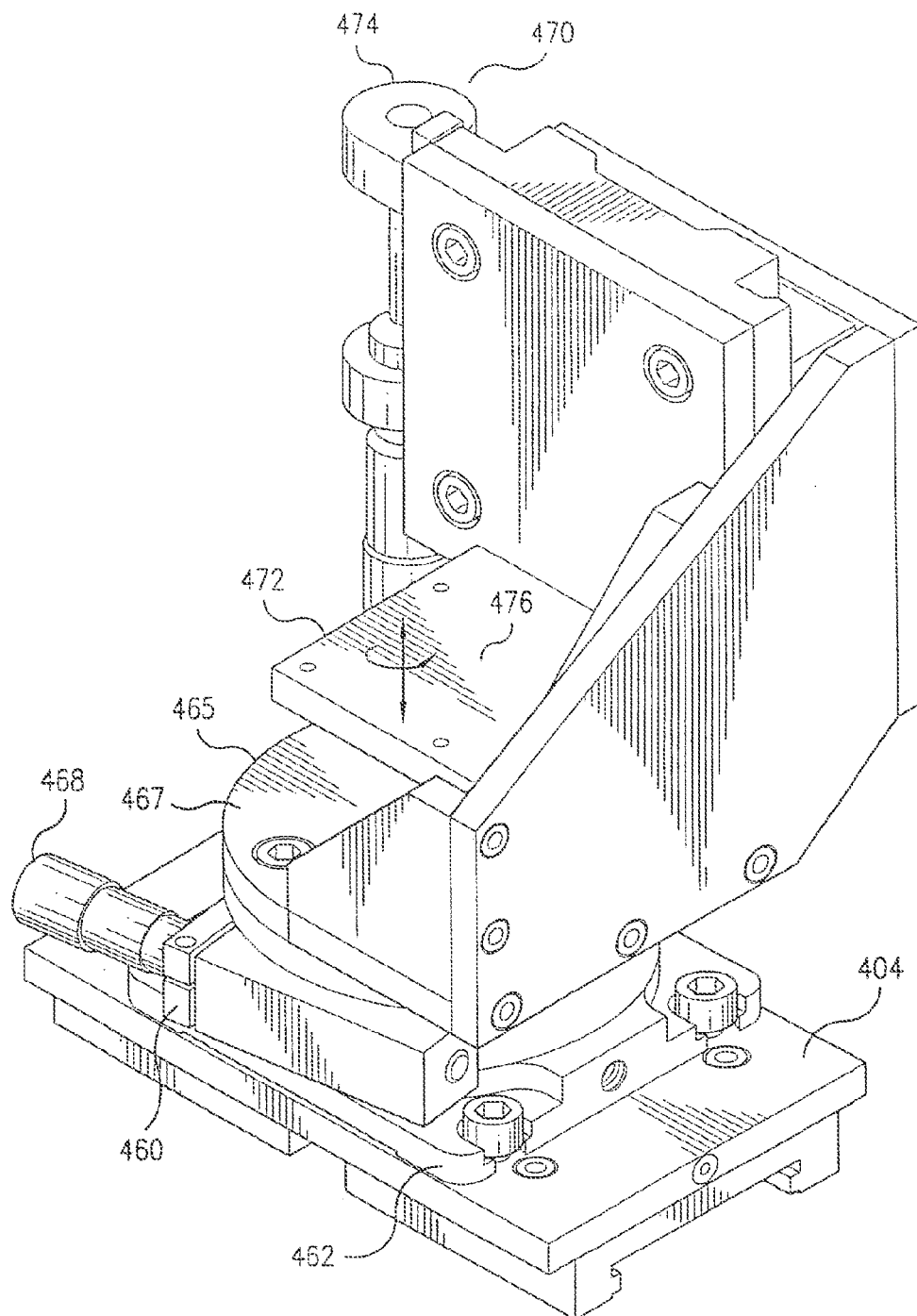


FIG. 34

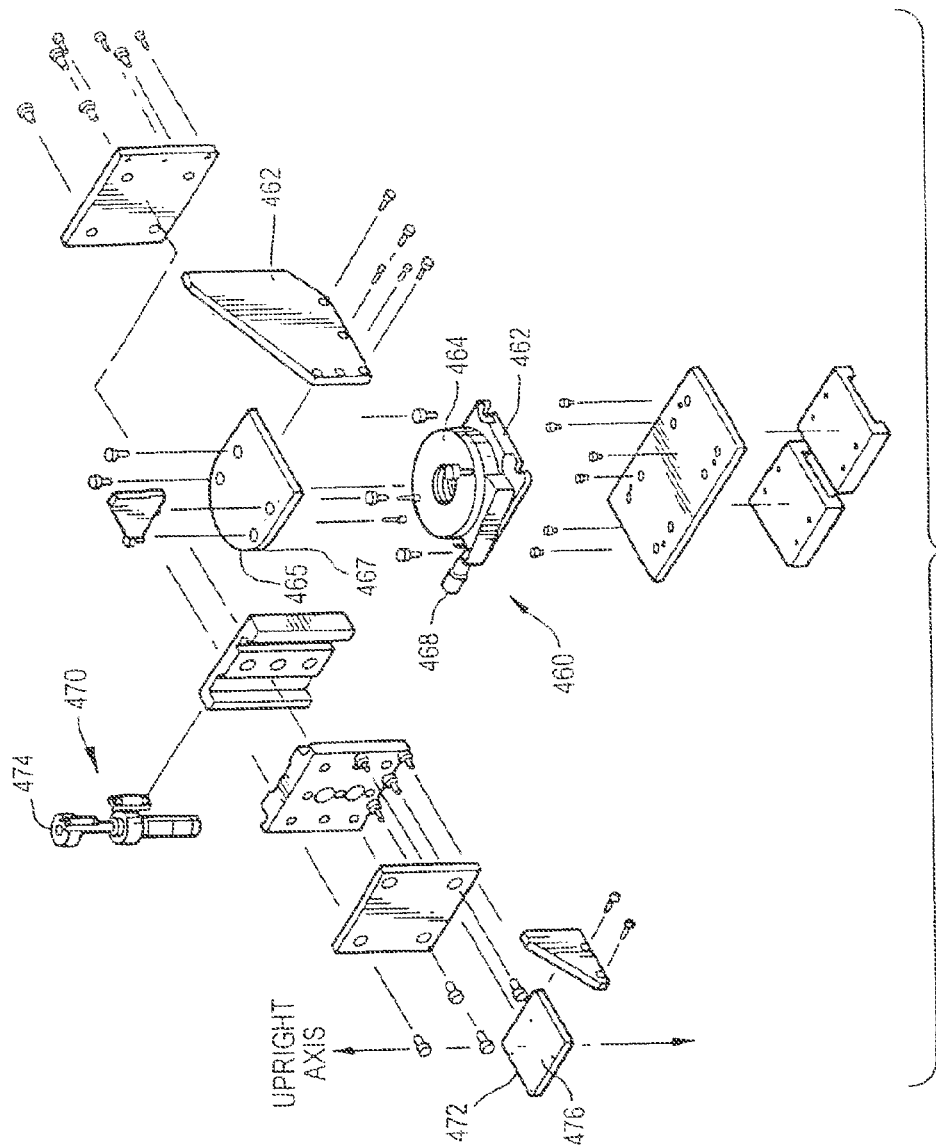


FIG. 35



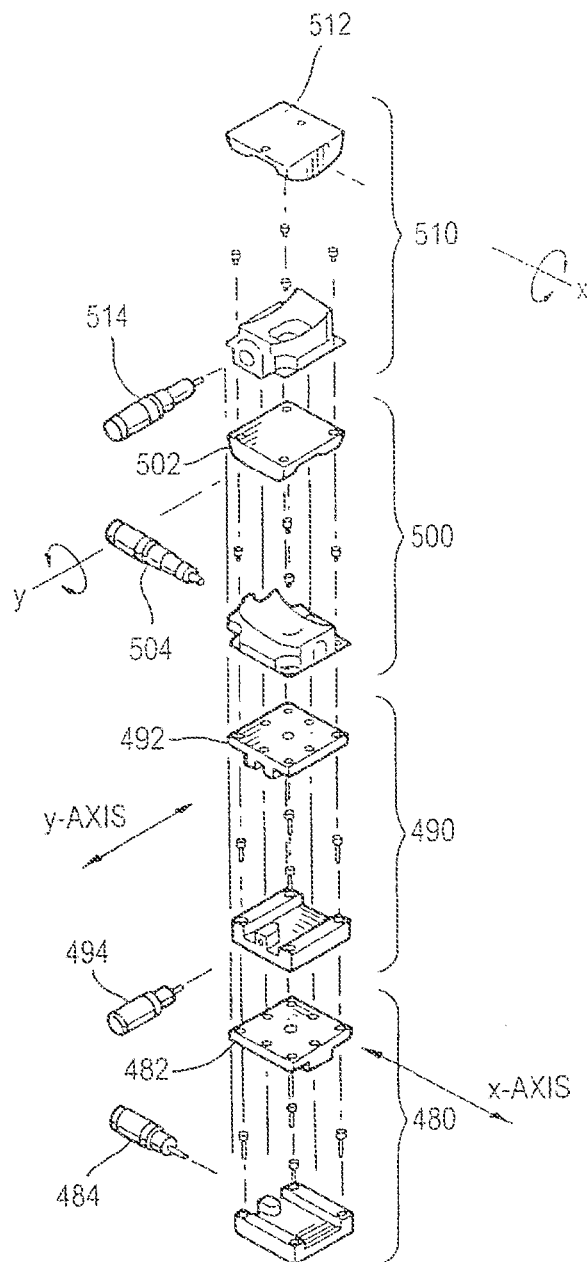


FIG.37

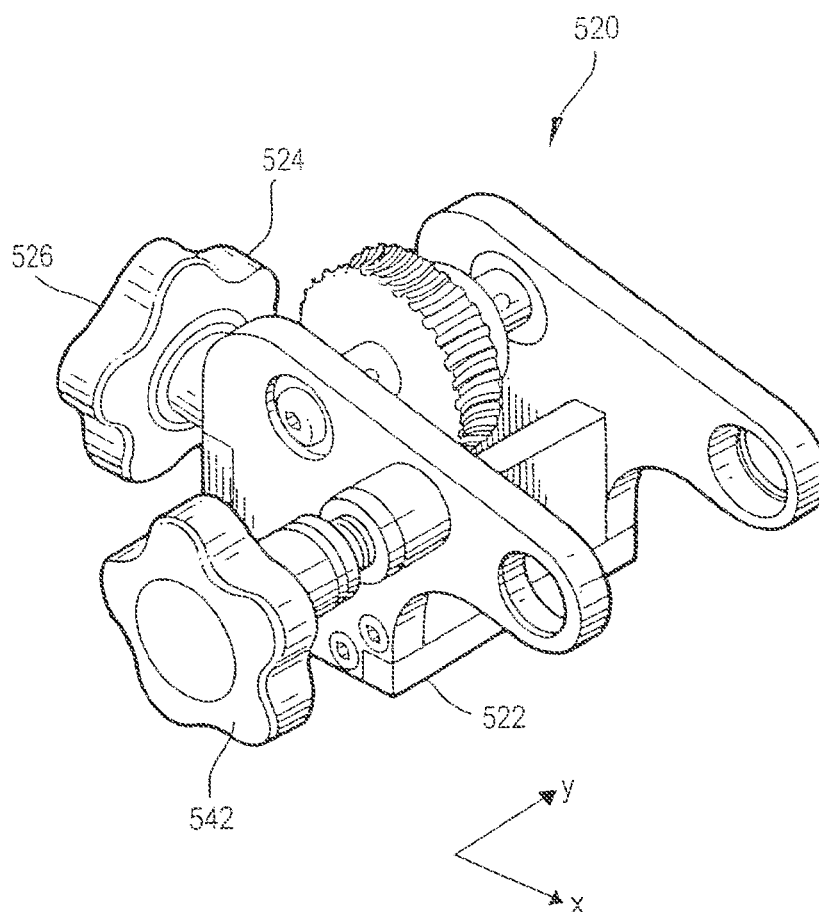


FIG.38



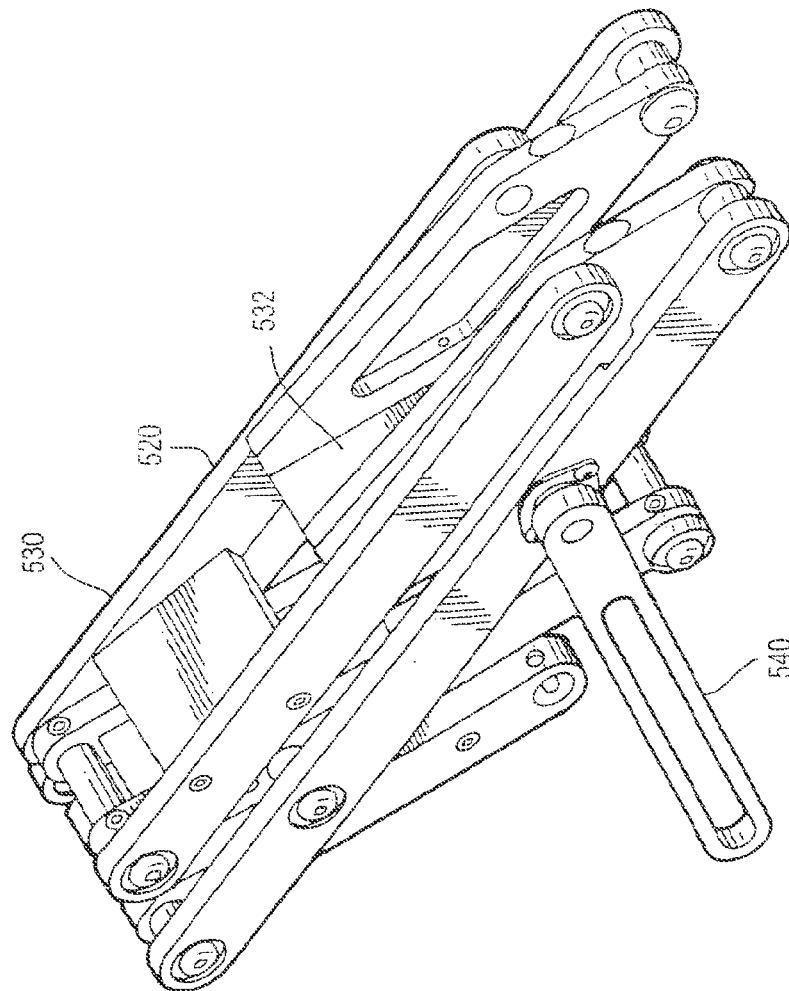


FIG. 39

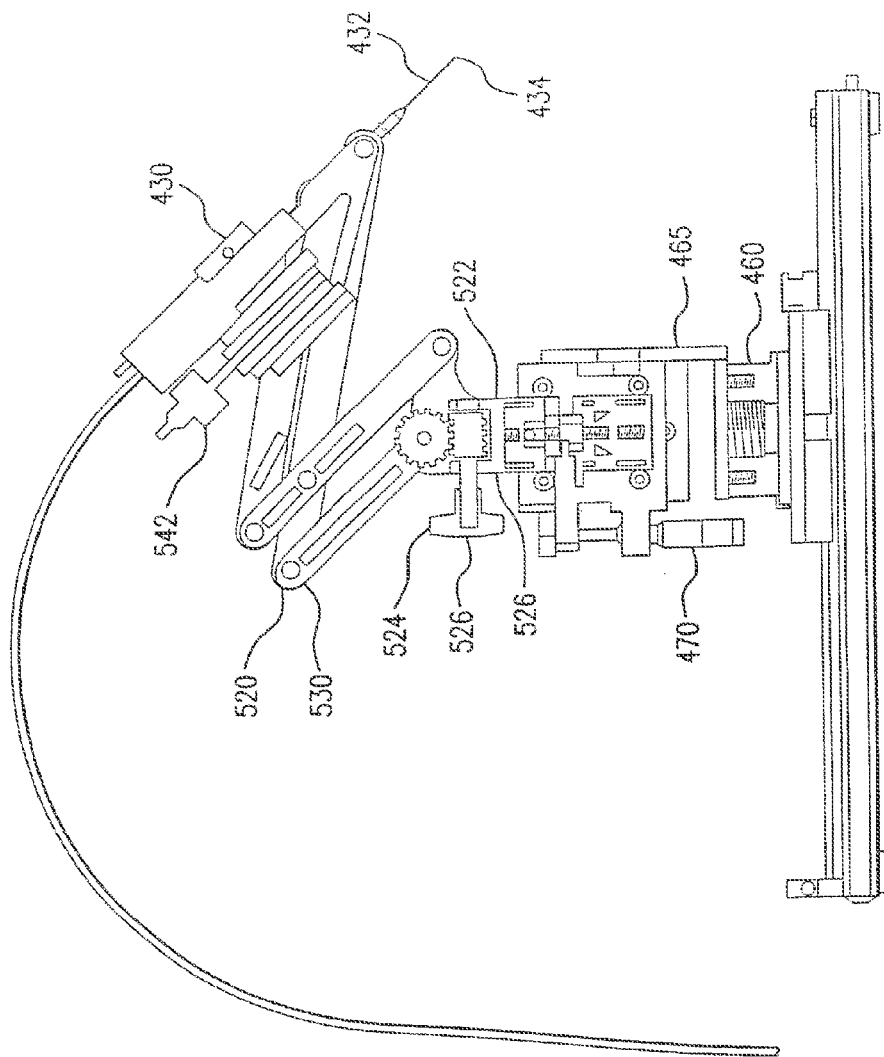
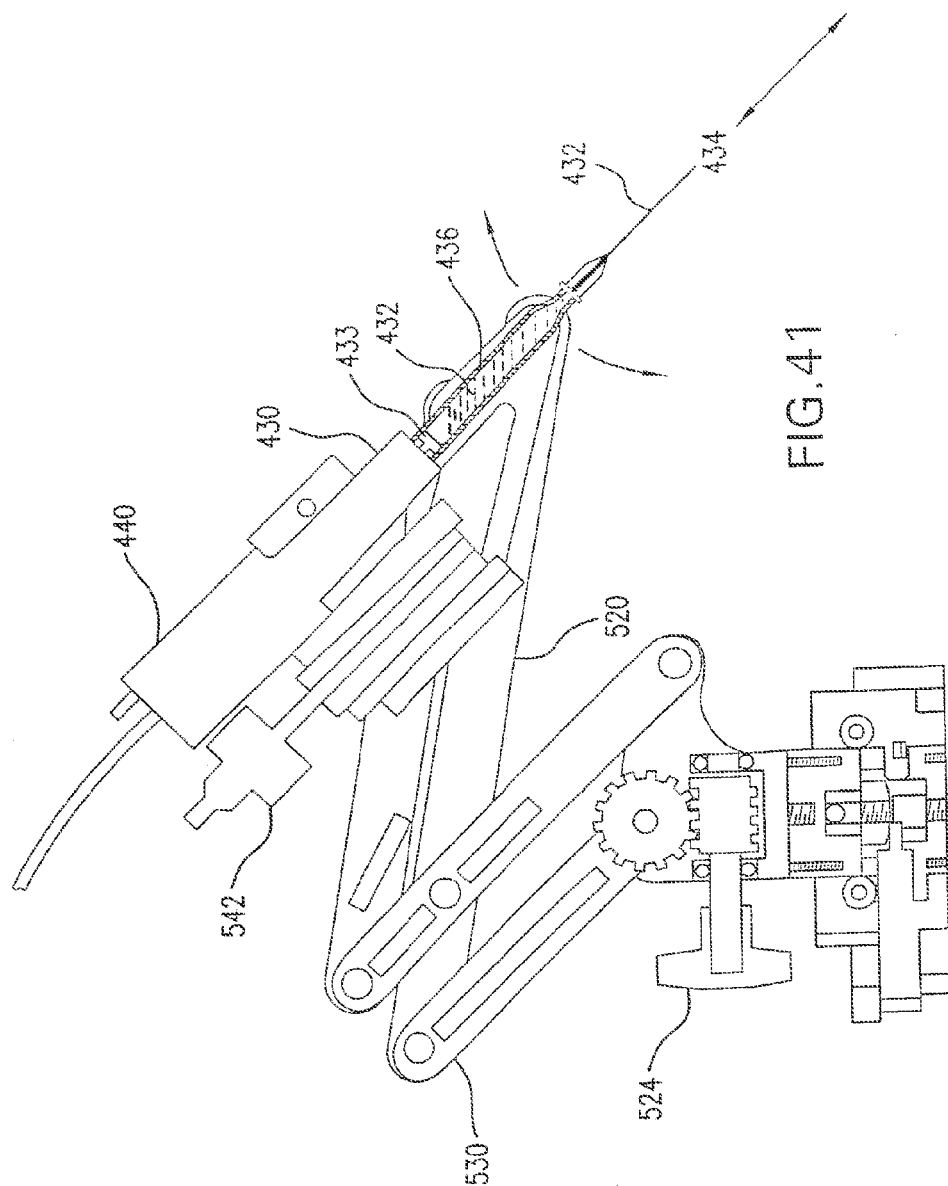


FIG. 40



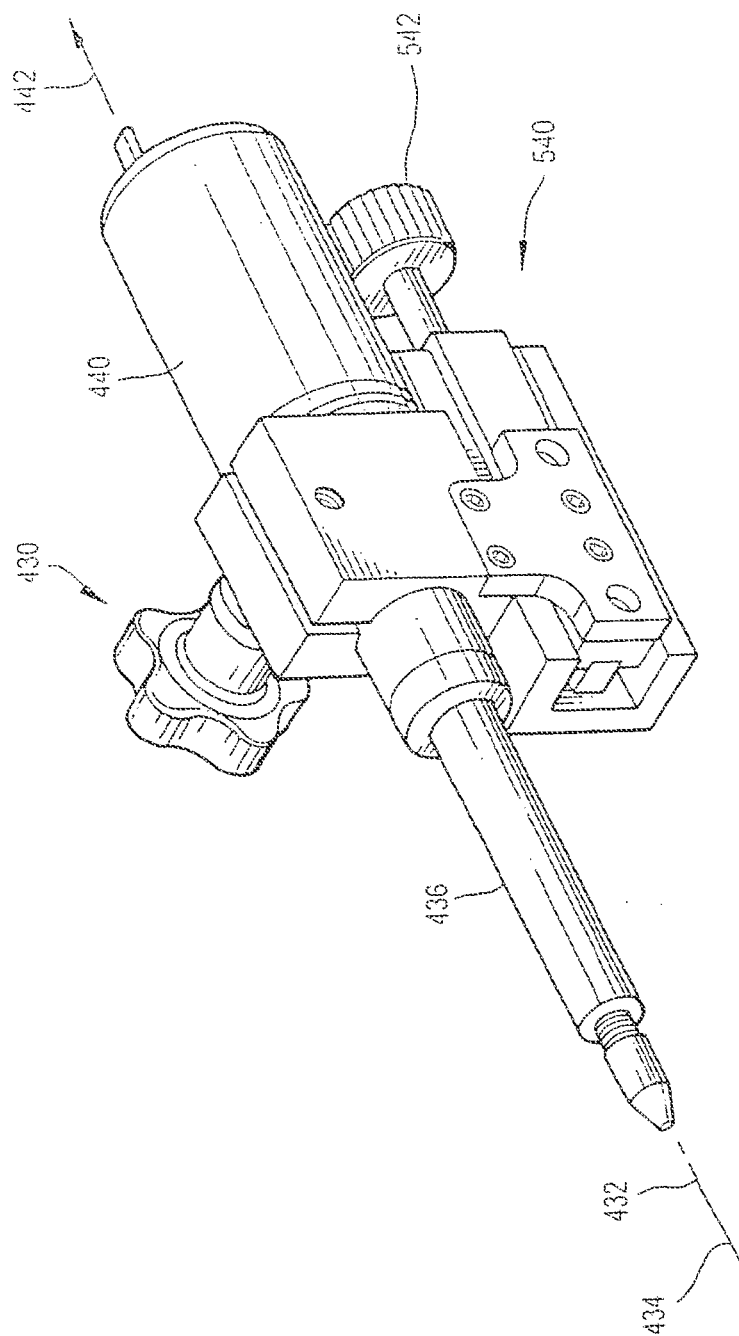


FIG. 42

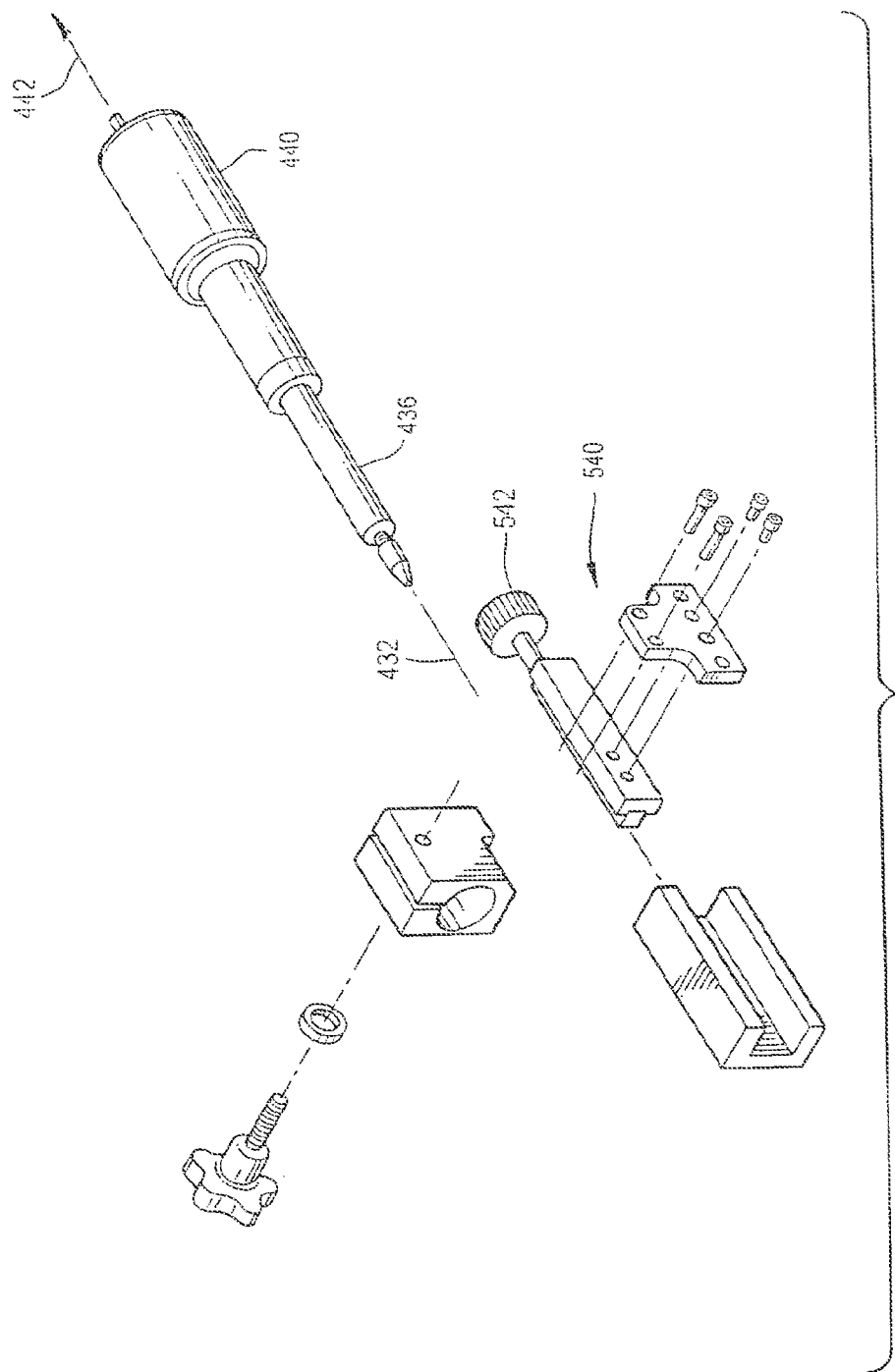
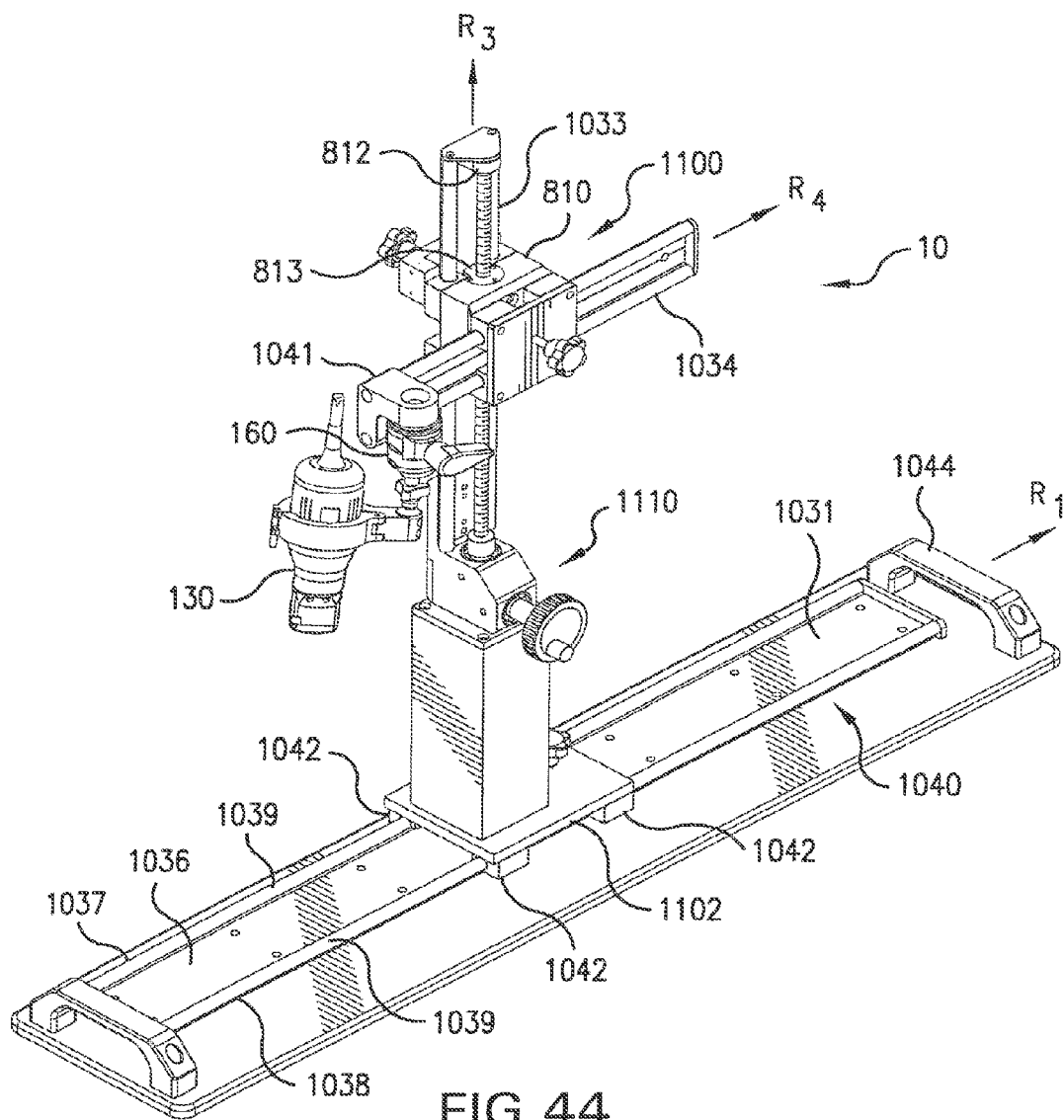
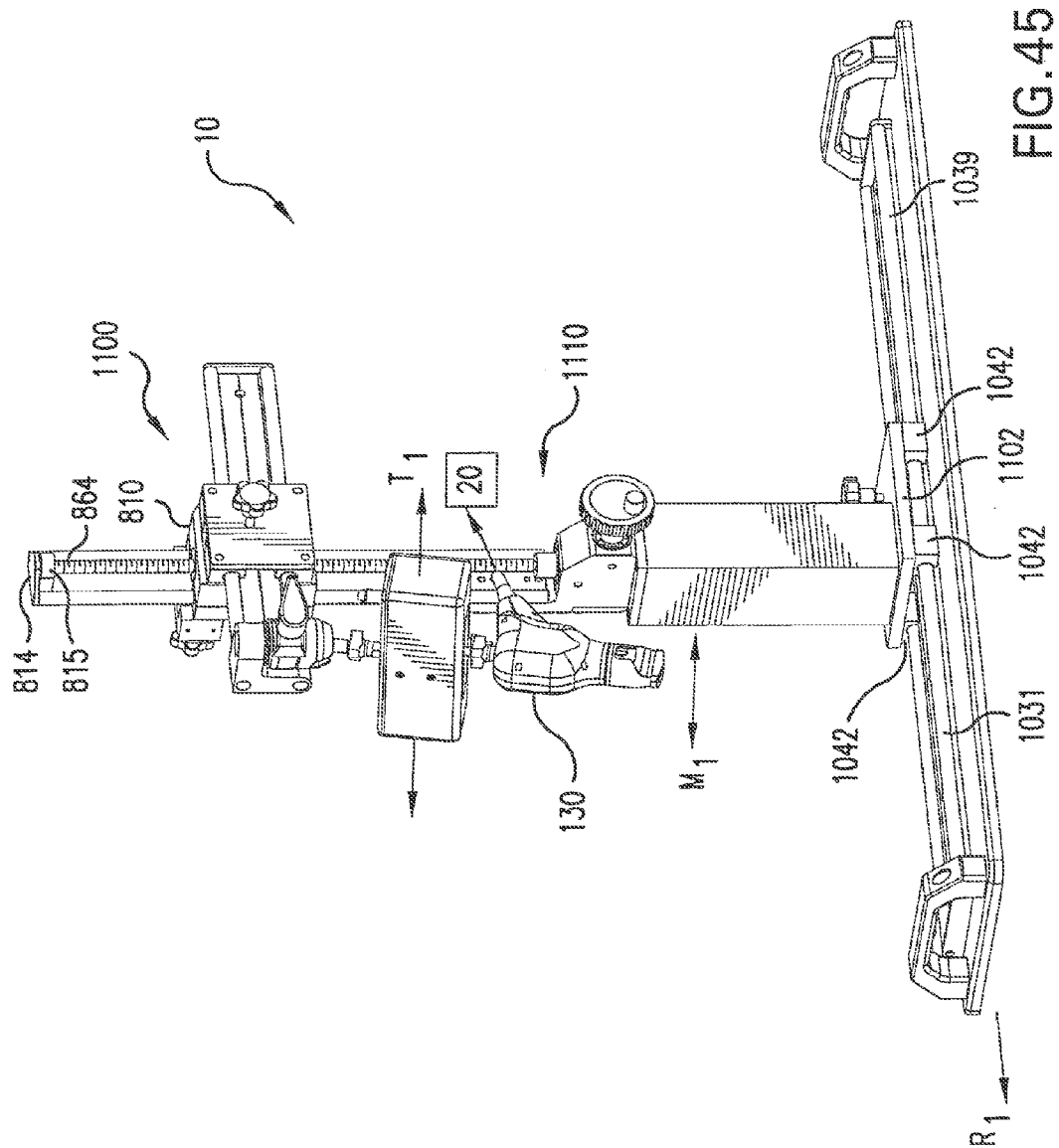
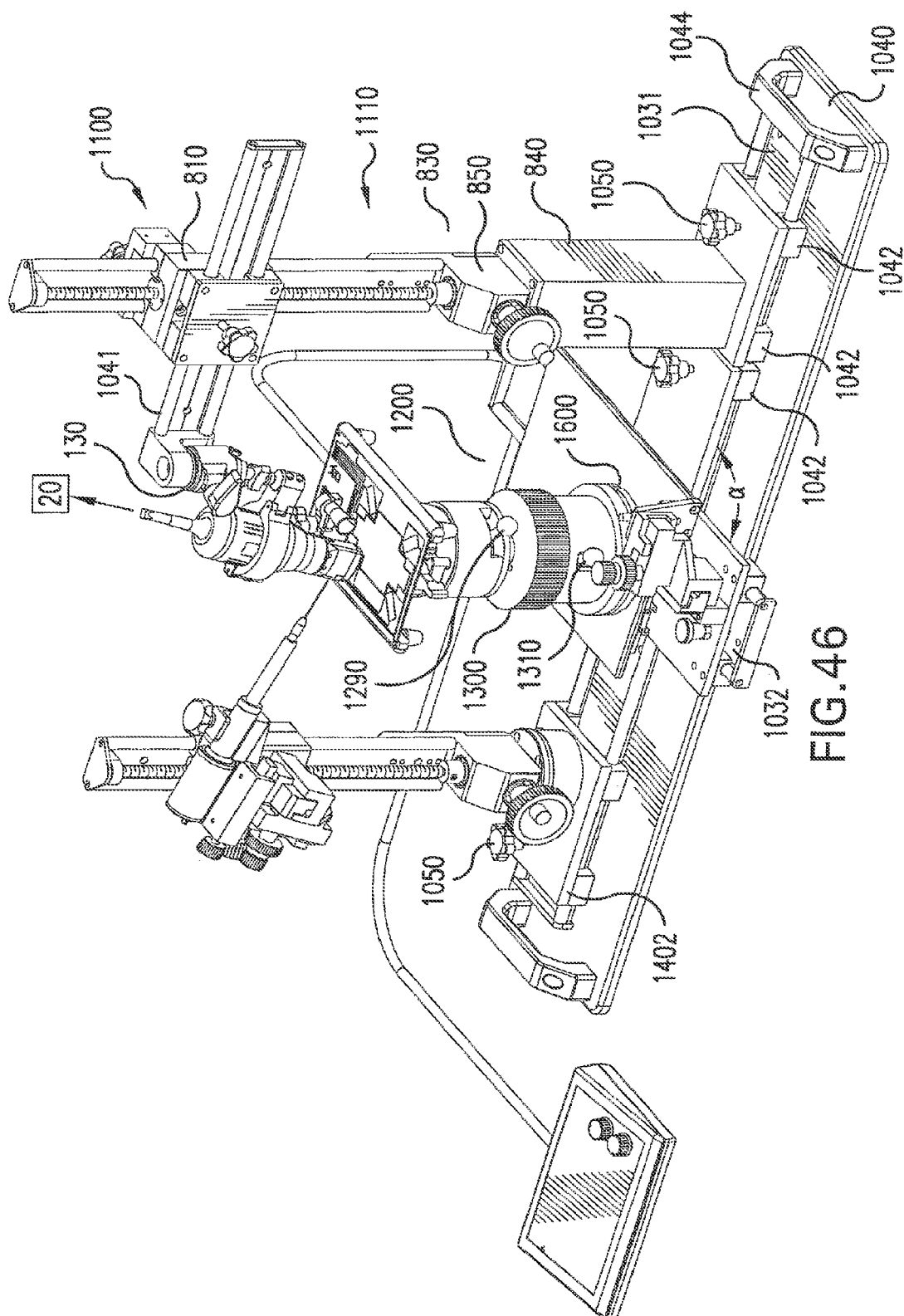


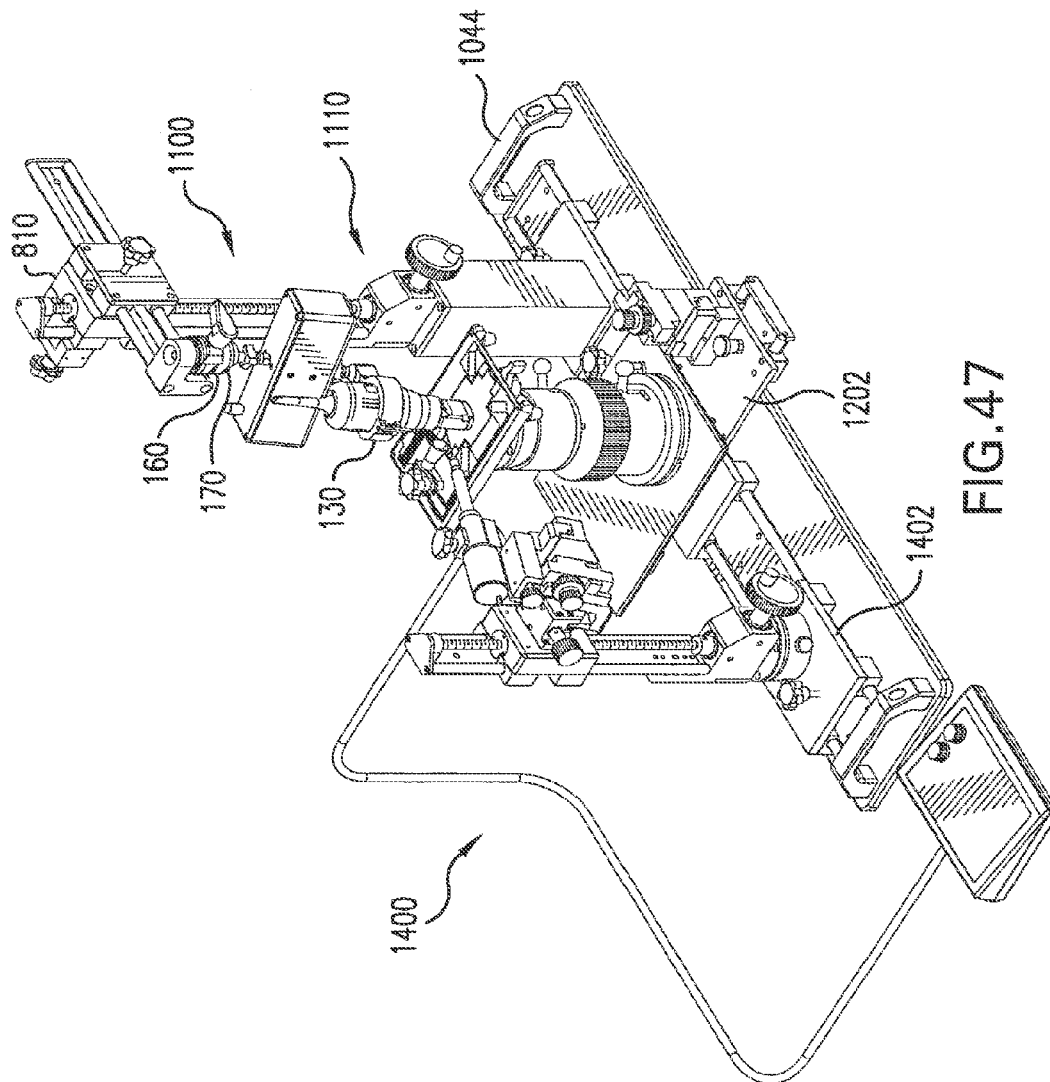
FIG. 43

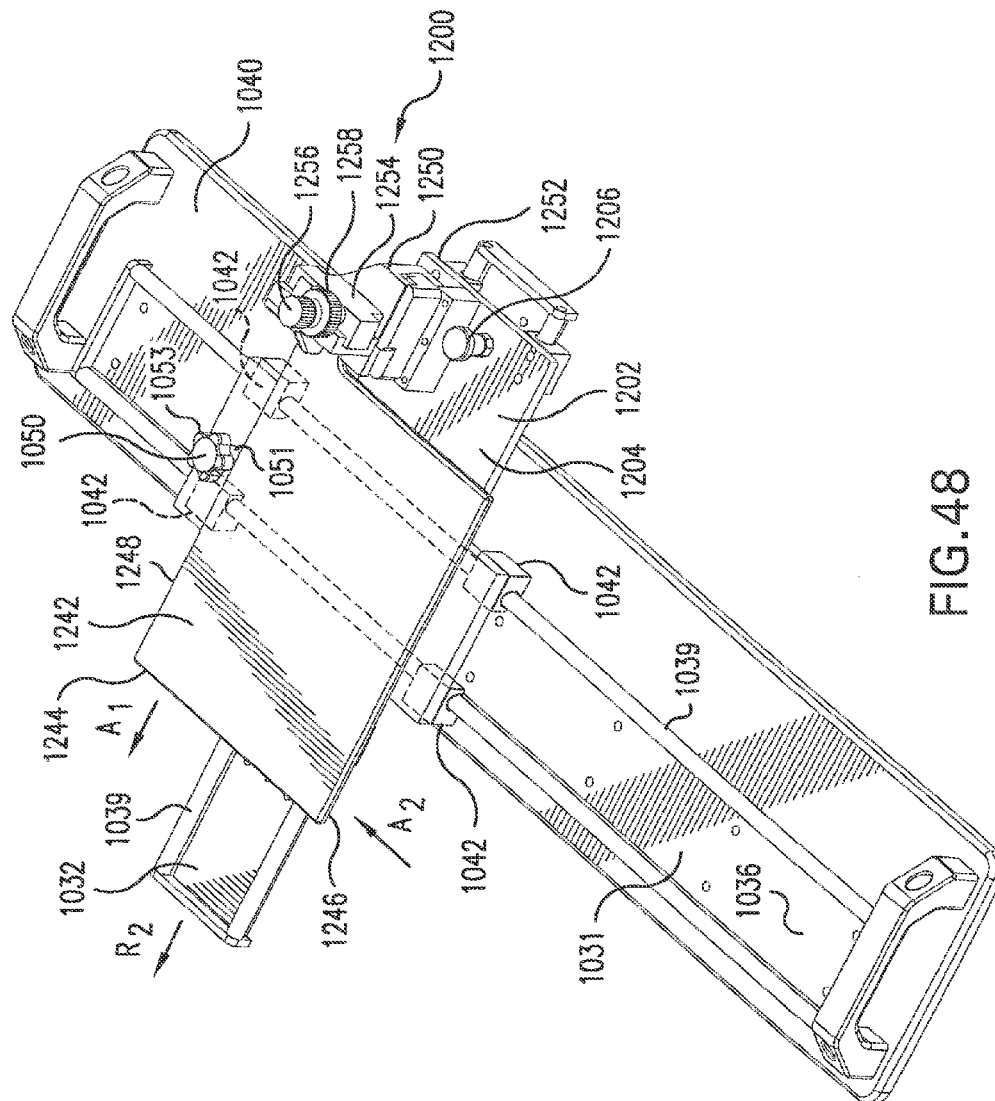












846.45

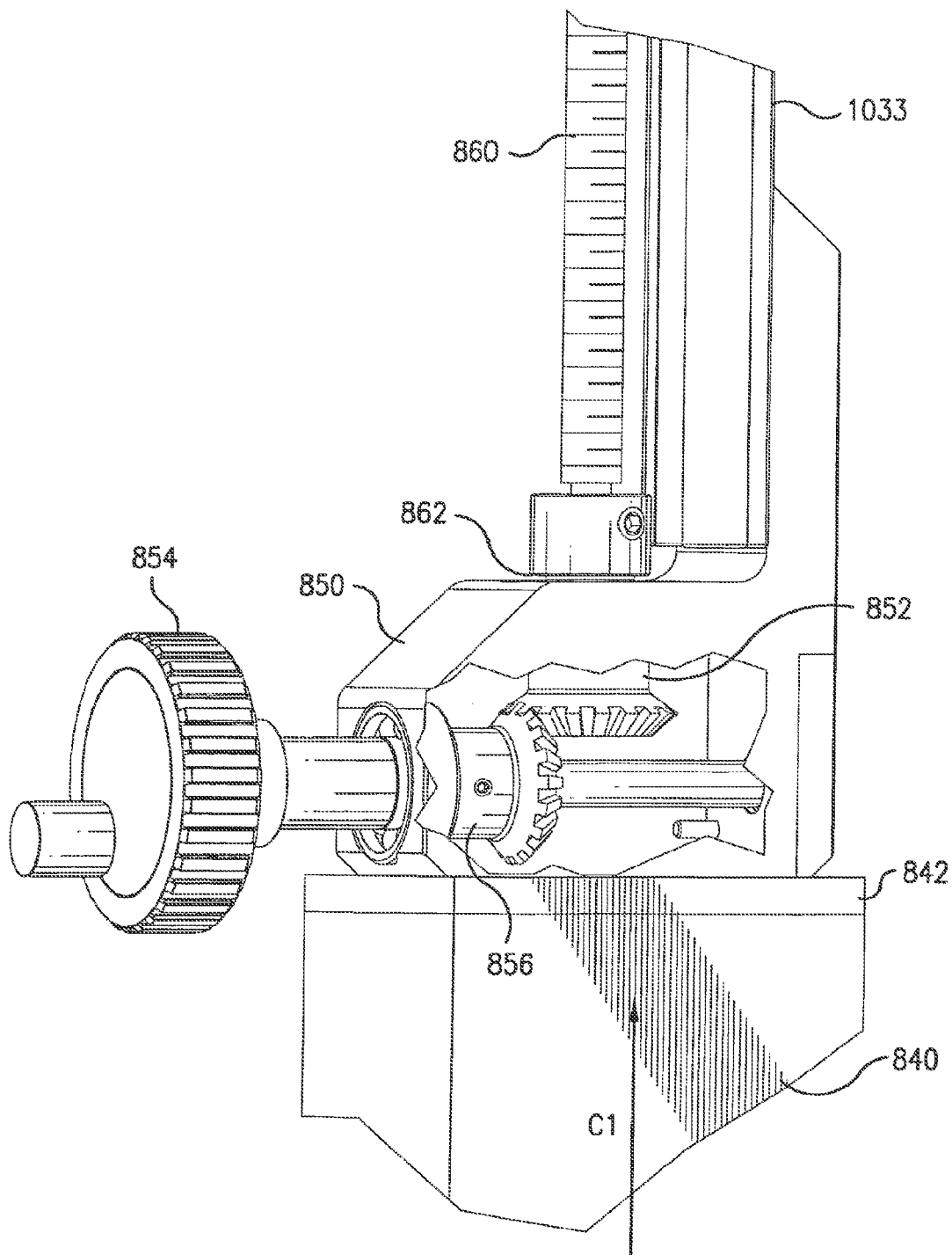


FIG. 49

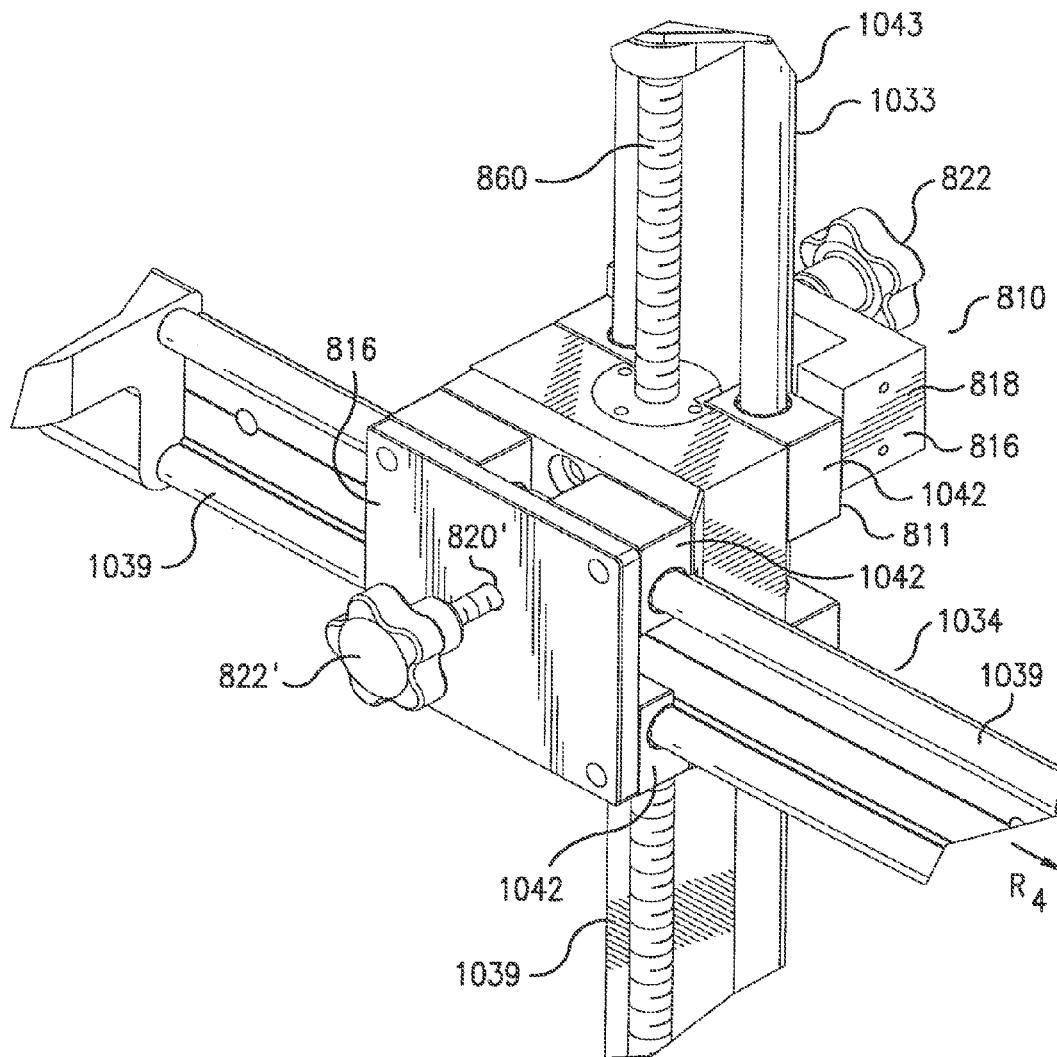
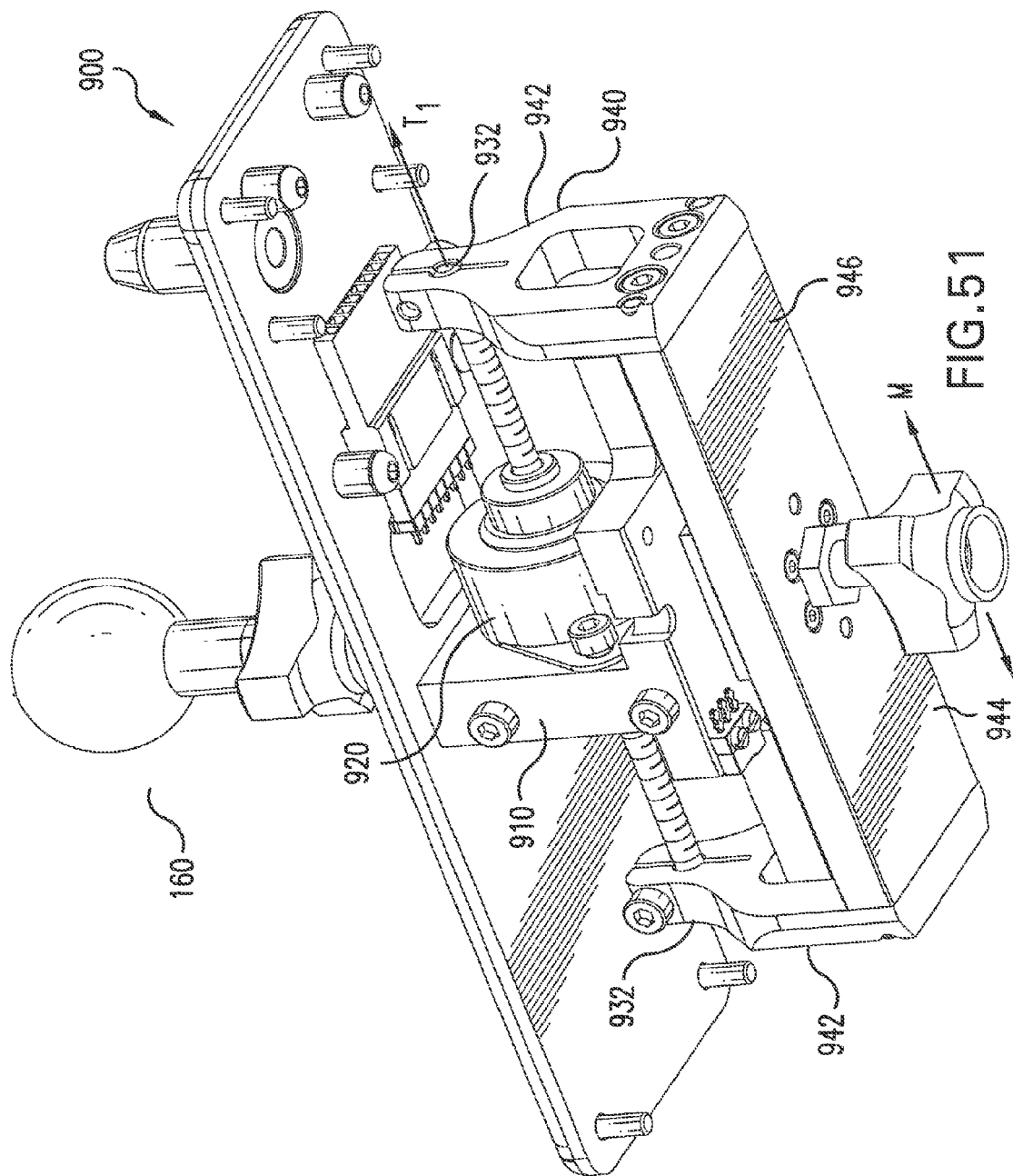


FIG. 50



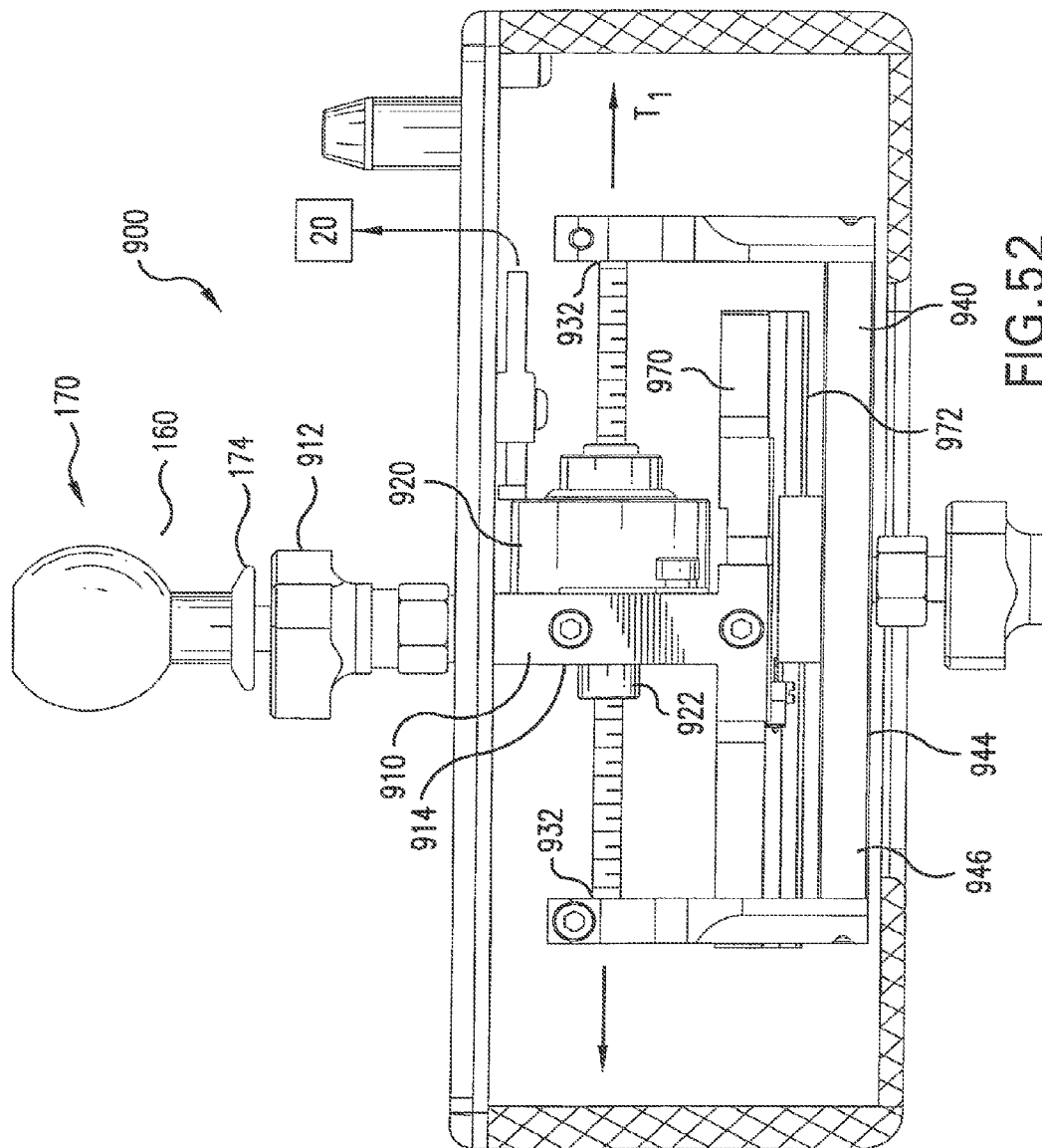
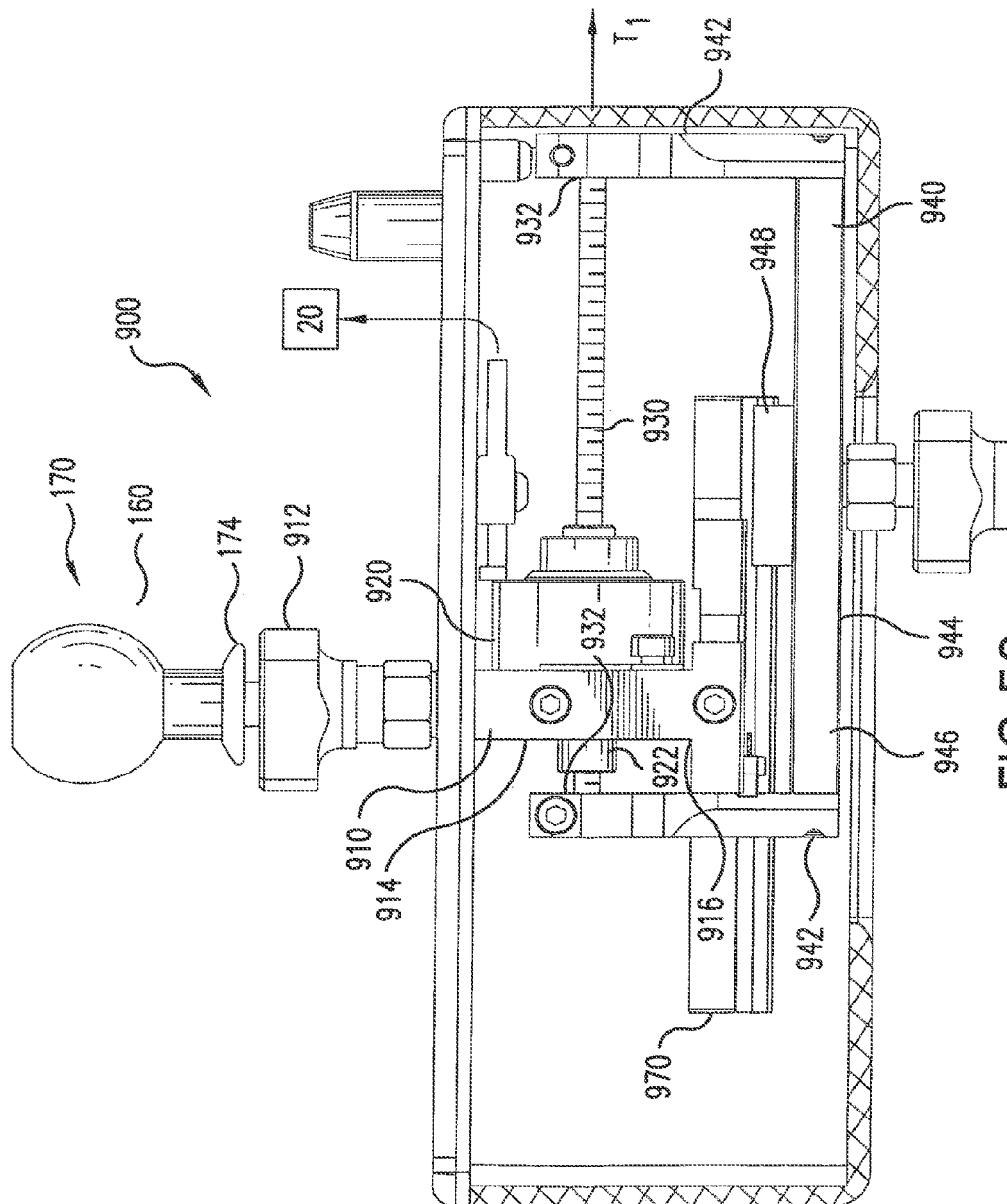


FIG. 52



350

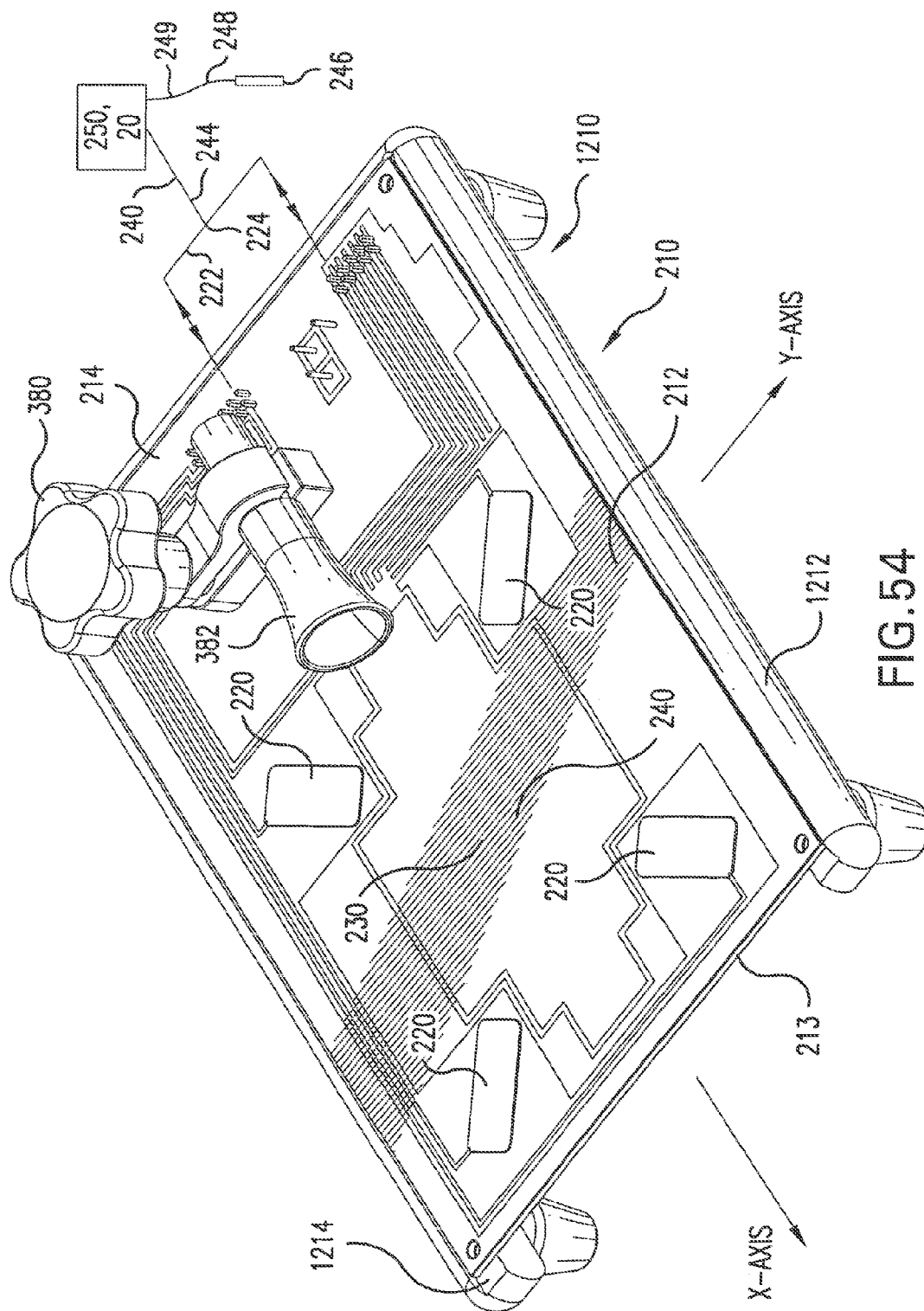


FIG. 54



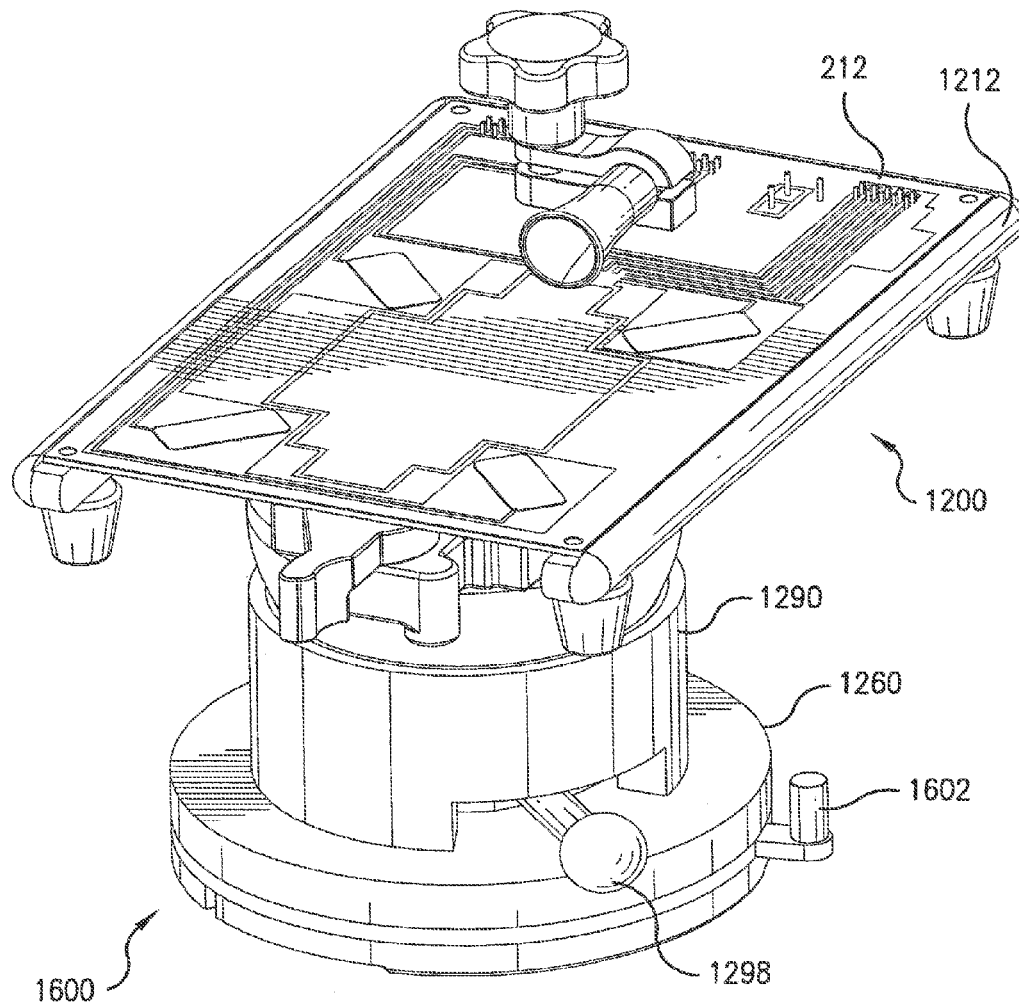


FIG. 55

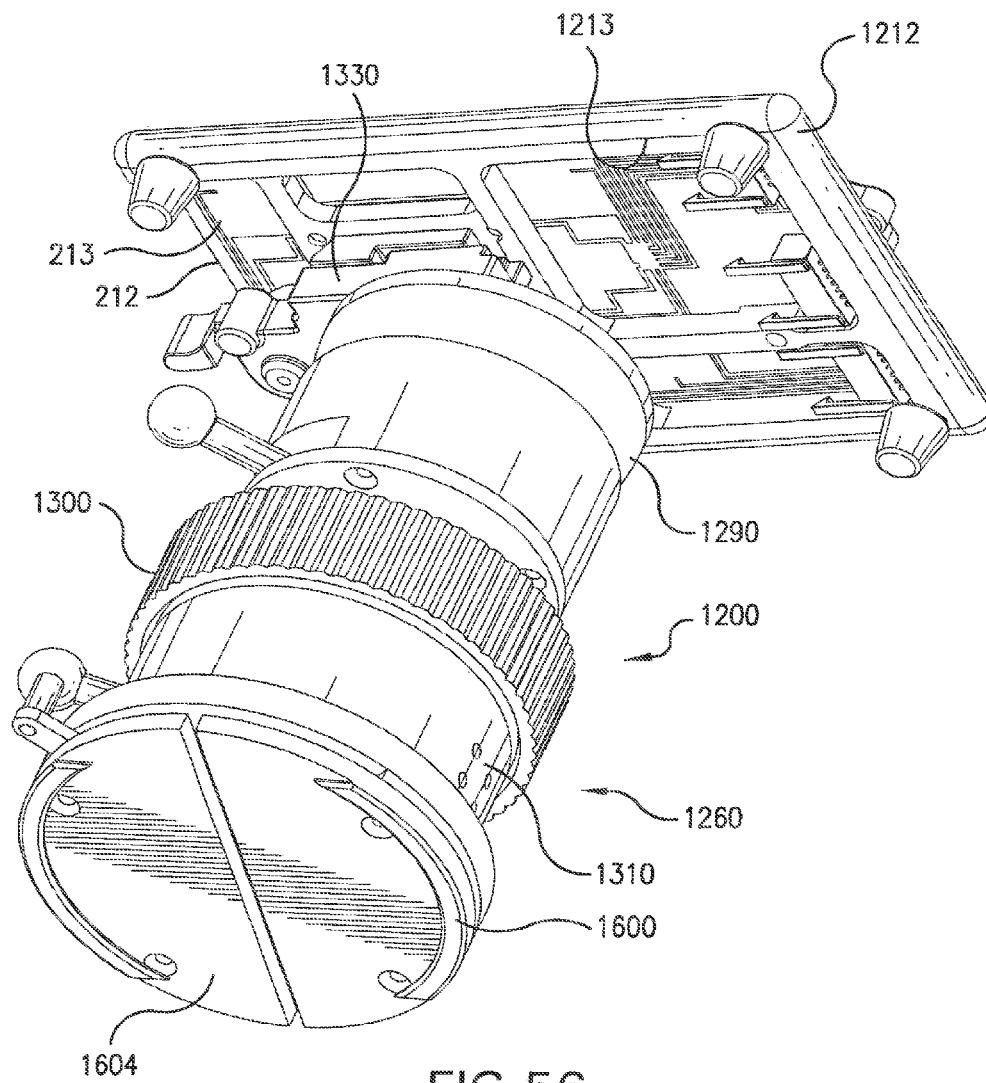


FIG. 56

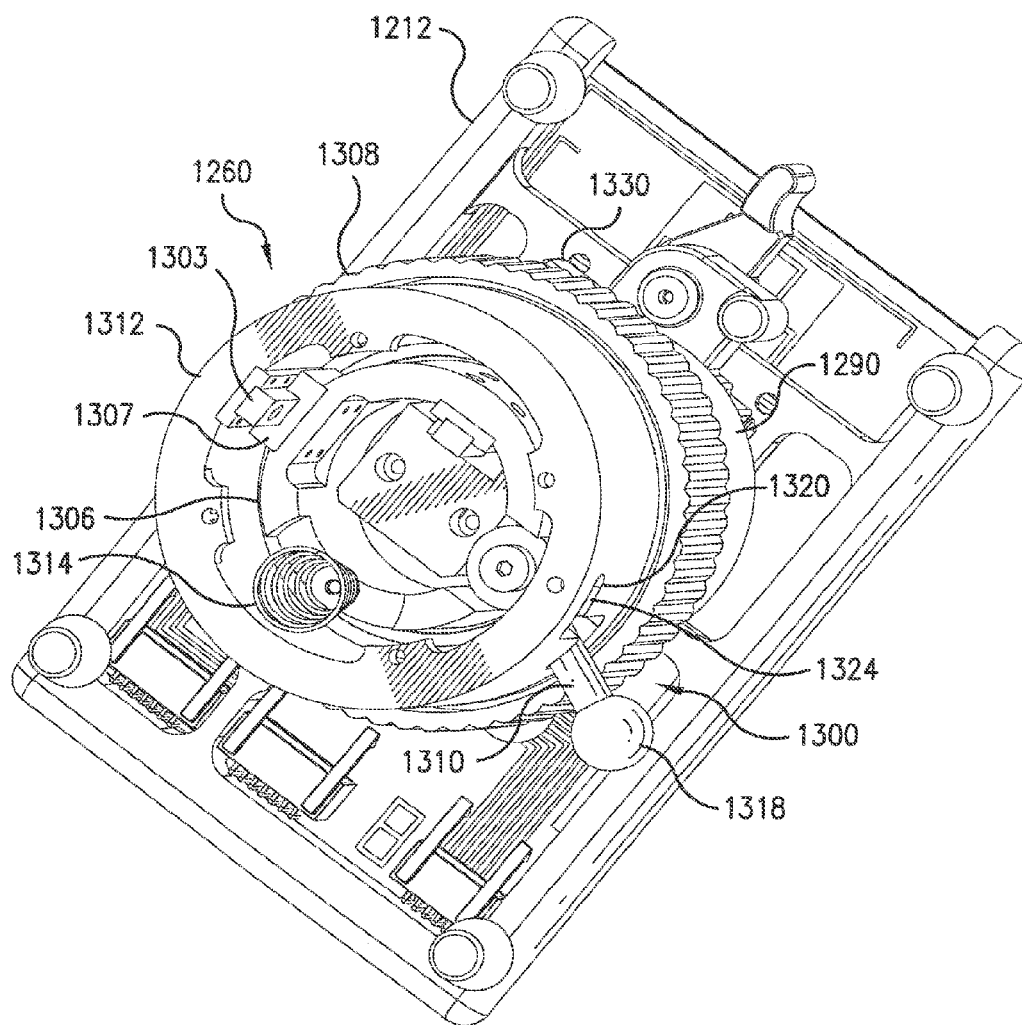


FIG. 57

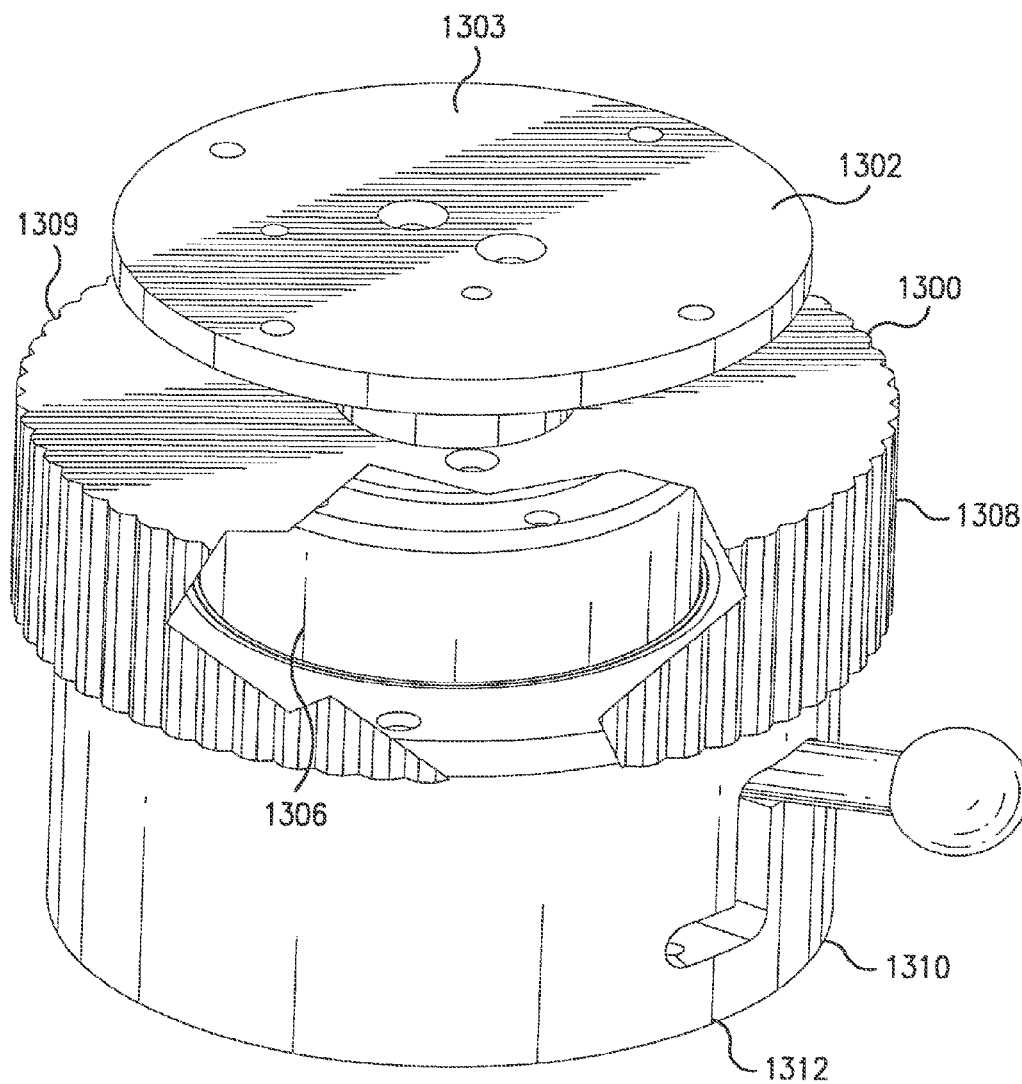
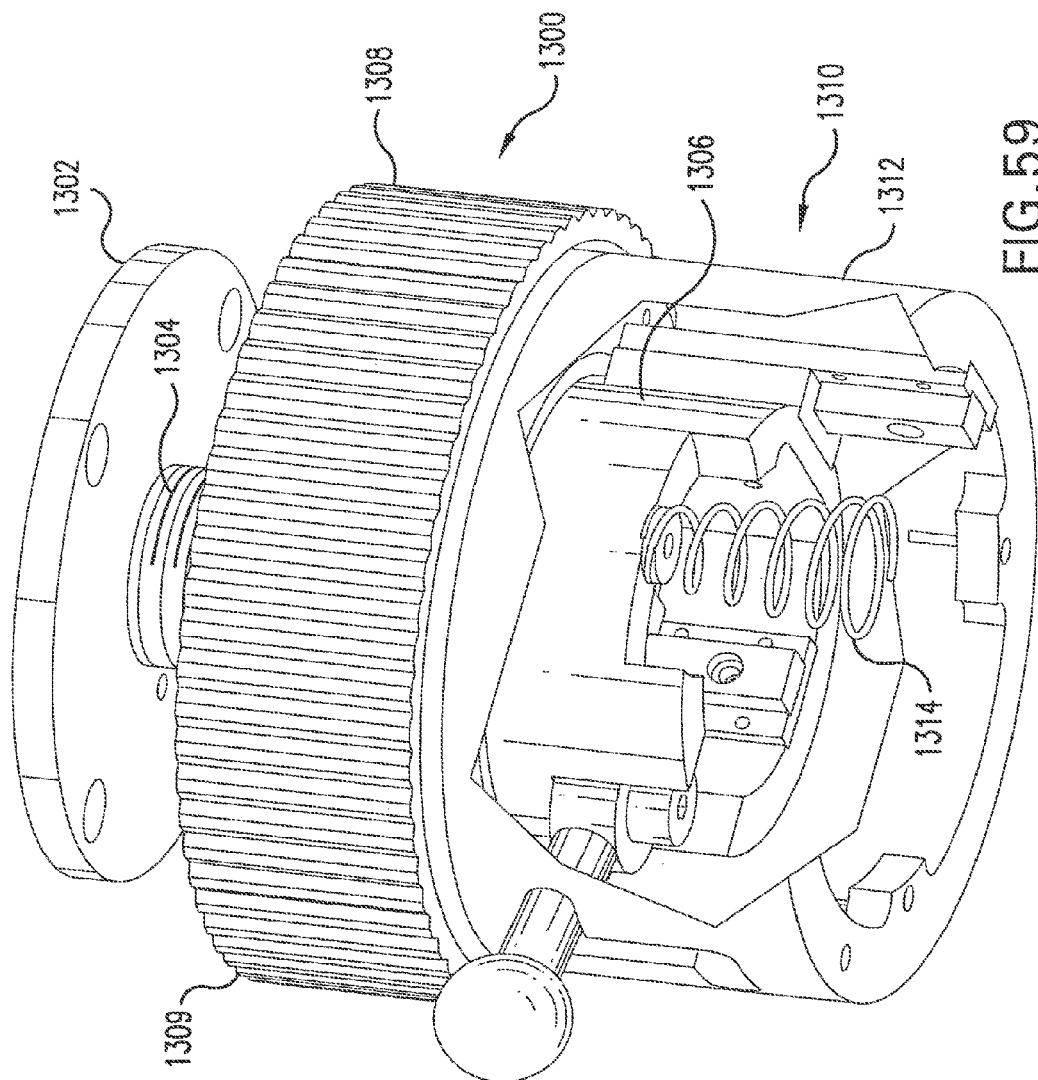
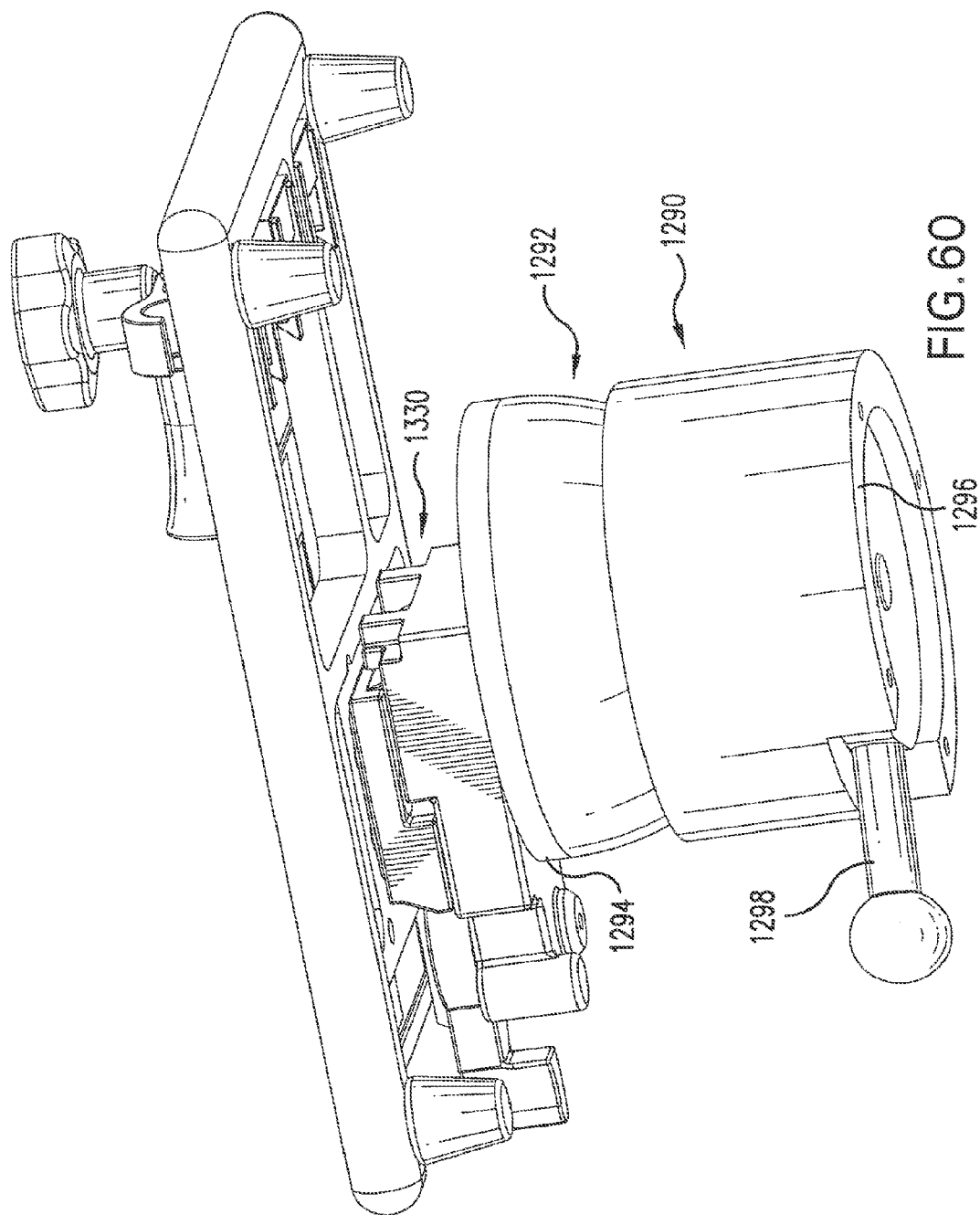
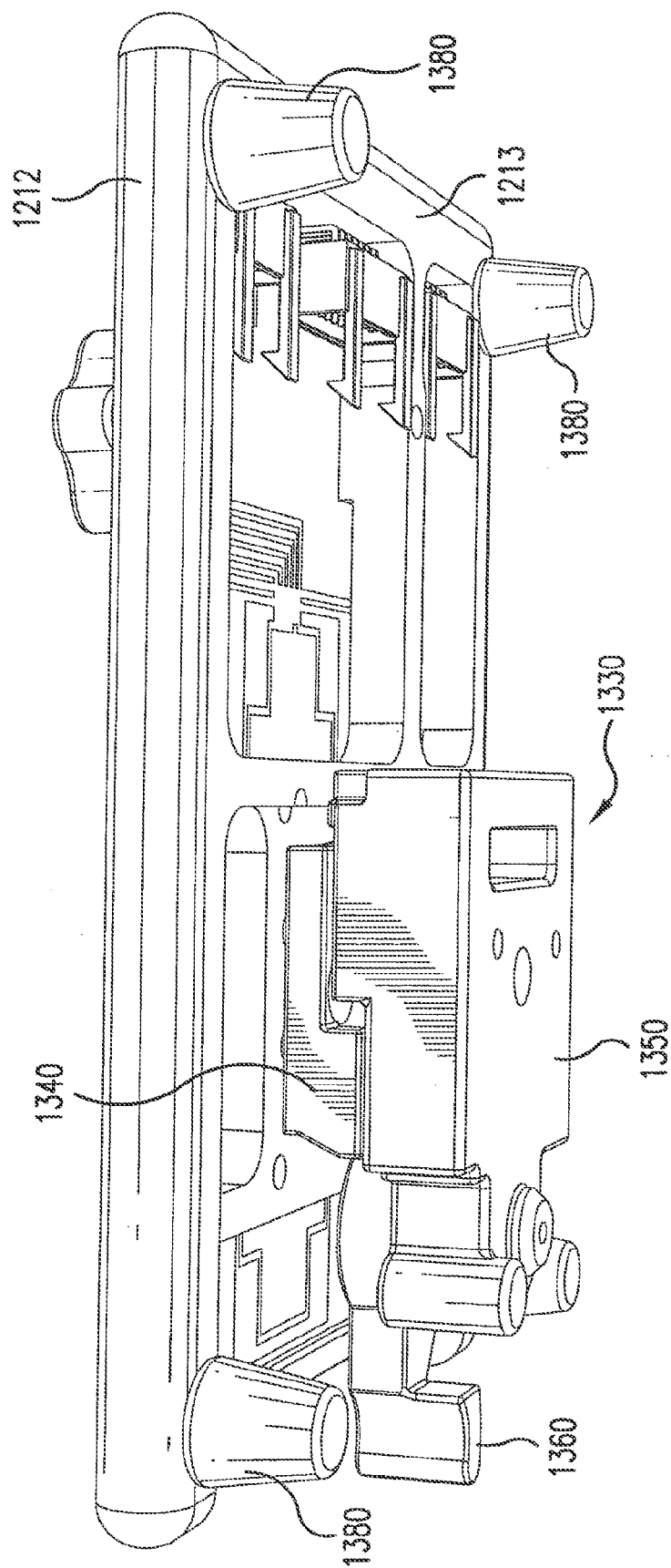
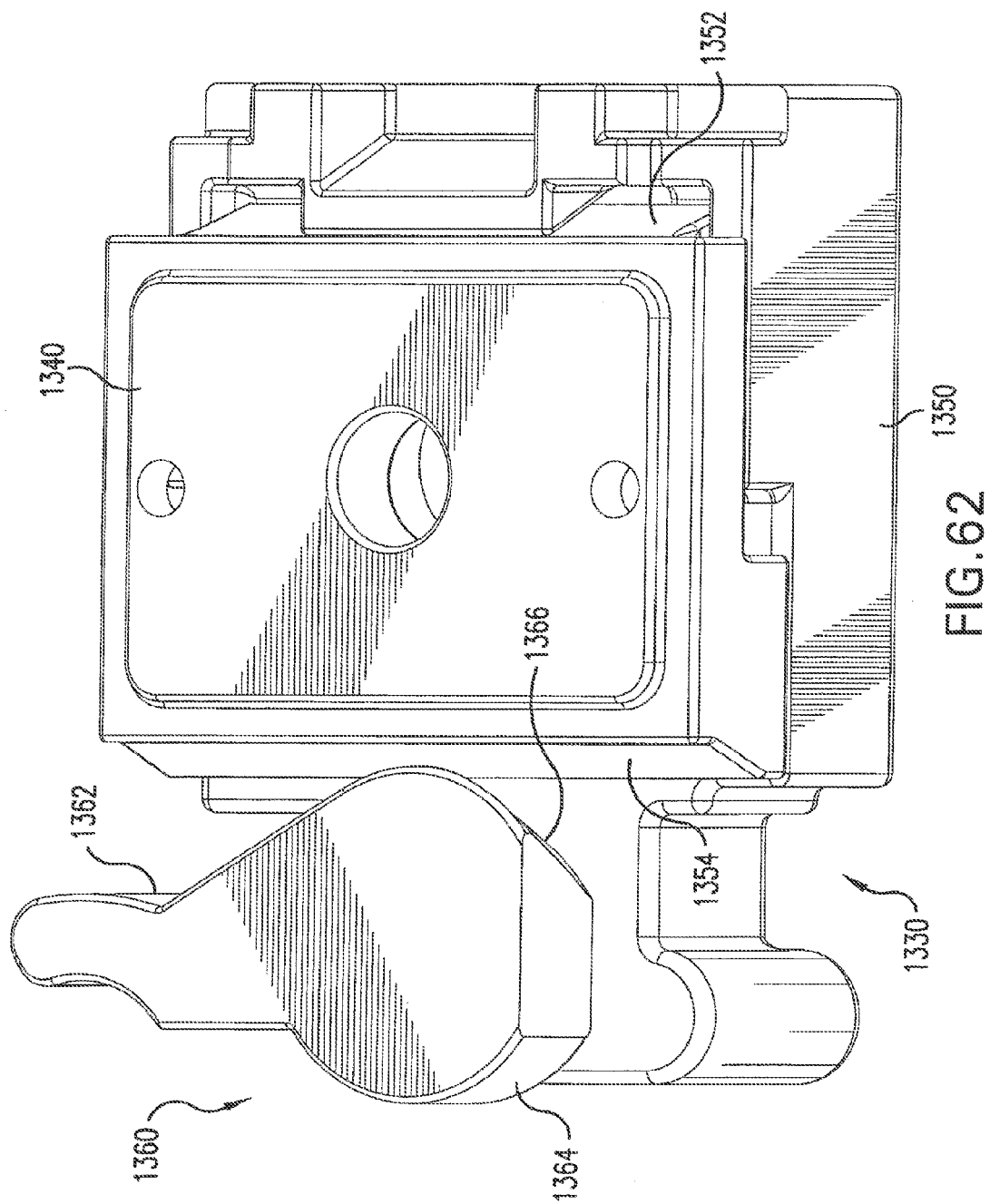


FIG.58

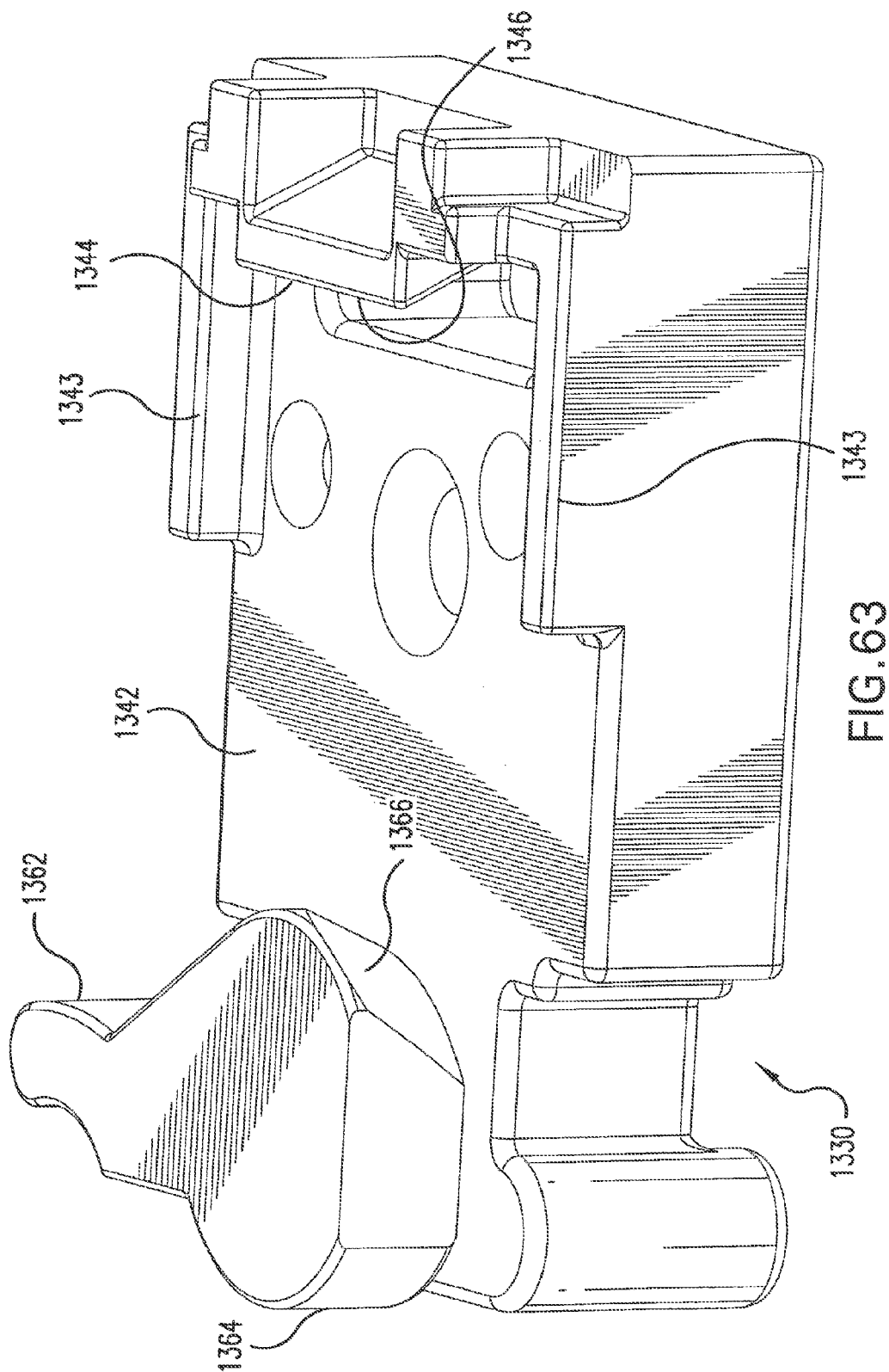


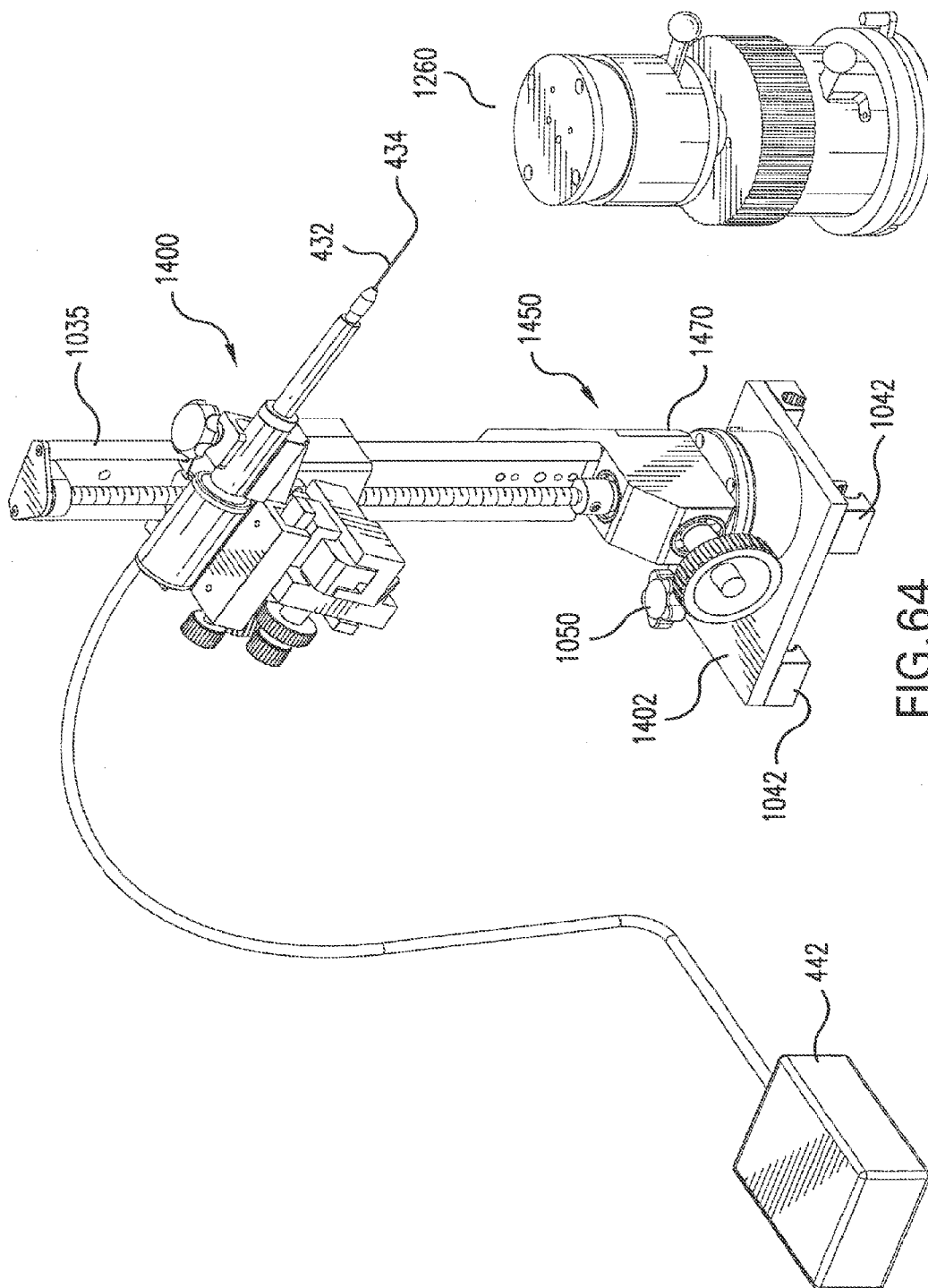












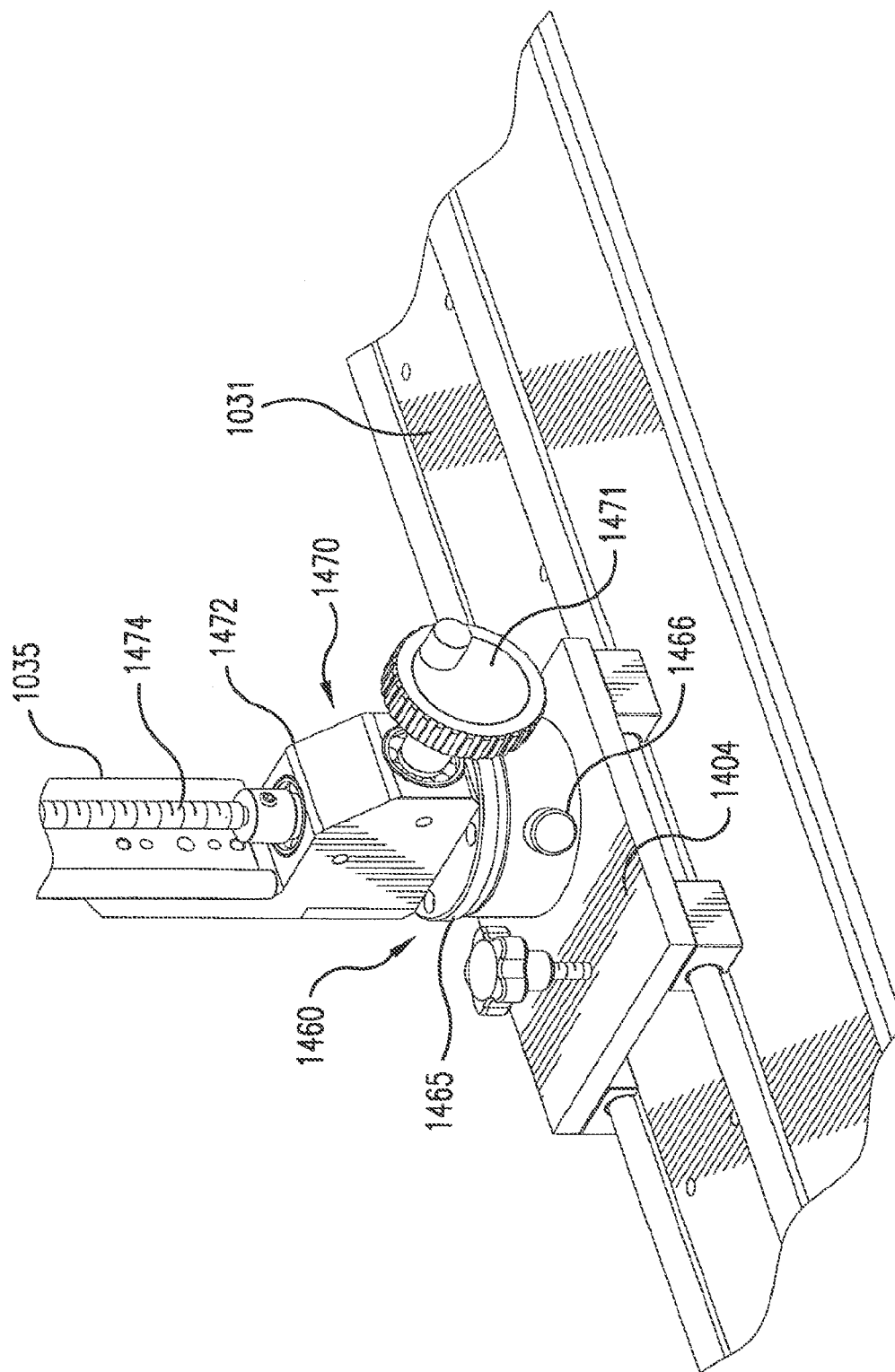


FIG. 65

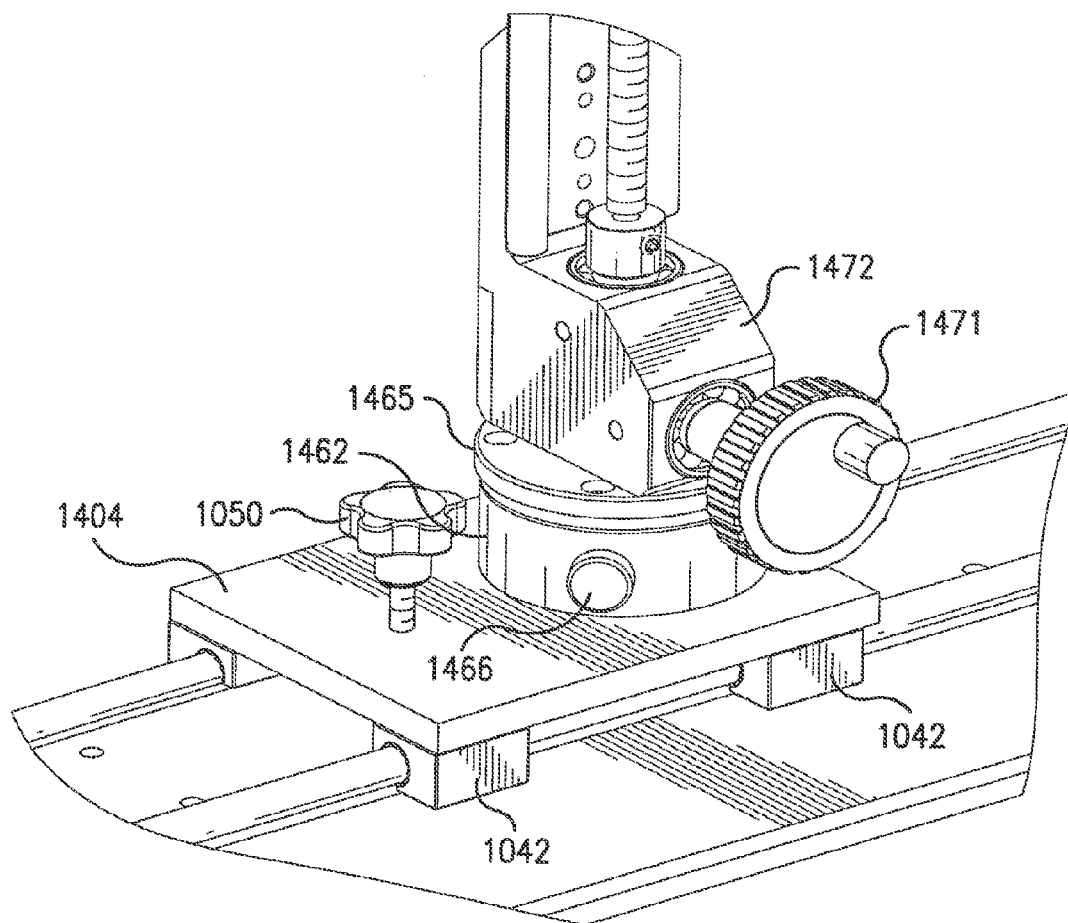


FIG. 66

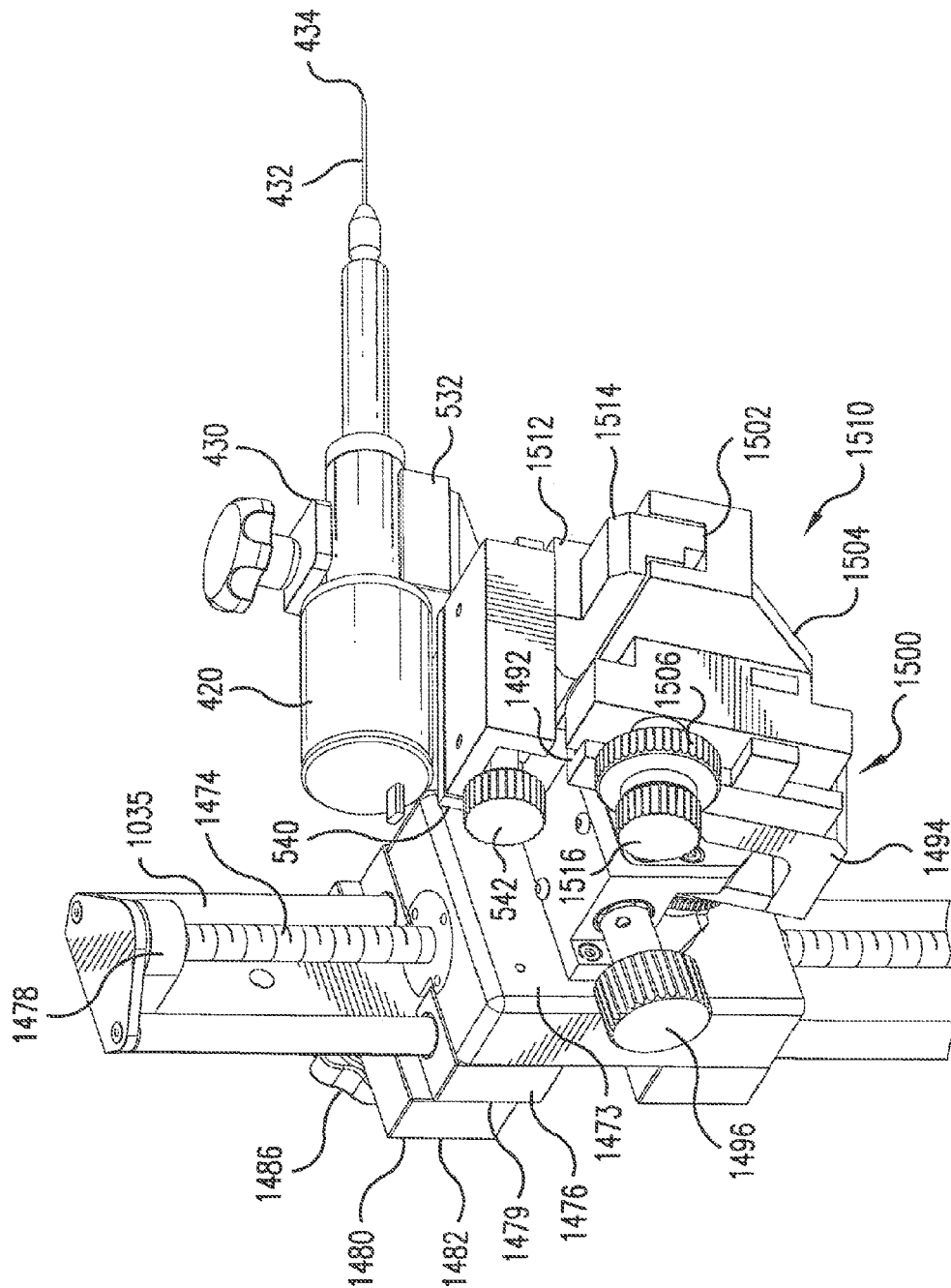


FIG. 7

# INTEGRATED MULTI-RAIL IMAGING SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/324,996 filed Dec. 13, 2013, now U.S. Pat. No. 8,945,014, which is a continuation of U.S. patent application Ser. No. 11/053,748, filed Feb. 7, 2005, now U.S. Pat. No. 8,078,256, which is a continuation-in-part of U.S. patent application Ser. No. 10/683,168 filed on Oct. 10, 2003, now U.S. Pat. No. 7,133,713, which claims priority to and the benefit of U.S. Provisional Application No. 60/417,167 filed on Oct. 10, 2002; U.S. Provisional Application No. 60/468,959 filed on May 9, 2003; U.S. Provisional Application No. 60/417,185, filed on Oct. 10, 2002; and U.S. Provisional Application No. 60/468,960, filed on May 9, 2003, all of which are incorporated in their entireties in this document by reference.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a small-animal imaging system, and more particularly to a multi-rail imaging system for maintaining a desired image plane during an imaging session.

### 2. Description of the Prior Art

Over the past few years researchers in disciplines as diverse as neuroscience, developmental biology, genetics, and oncology have struggled with the challenge of injecting microliter and nanoliter quantities of fluid into discrete regions of organ systems. With the development and launch of ultrasound biomicroscopy (UBM) technology in the small animal imaging marketplace, the capacity to non-invasively observe, in real-time, the position of a needle or probe relative to an organ became a reality. One disadvantage with present positioning systems for animals is that straightforward repeatability of position with different animals is not possible.

For example, during injections procedures, a common problem has been the challenge of aligning a needle guidance device, which injects very small quantities of fluid, with a UBM scanhead device. Micromanipulation of both devices is necessary to help ensure that the injector needle of the needle guidance device lies within the same plane as the ultrasound scanhead so that the operator can guide the needle to the organ of interest. Consequently, this is a laborious and time-consuming process, which is aggravated by the need to move both devices away from an animal handling device, upon which a small animal is mounted, when a different animal is to be scanned. Current systems use independent, non-integrated, positioning methods for the various devices used in the imaging session.

Much information and expertise is available on the sequence and the manipulation of the mouse genome. Because of the similarity between the mouse and human genomes, the mouse is used as a model for understanding human gene function, and a model for many human disease processes. Manipulations permitted by guided injection technique facilitate experiments to further the understanding of genome function, the functional stages of organ development, the differentiation of stem cells, and facilitate testing of new interventions for models of human disease. Ultrasound imaging can be used to generate a high resolution, cross sectional image in real-time so the imaging

system can be operated while a needle is introduced into the small animal that gives the operator immediate accurate feedback for positioning of the needle tip in the target space. However, there is a need for providing a system to provide for quick manipulation of imaging apparatus and, if used, injection apparatus, around a sequence of different animals in a time efficient manner.

There is a further need for a mounting table for handling of small animals, such as mice, rats, rabbits, and the like, in both a minimally stressful and time efficient manner during the course of an imaging session. Control of the animal's physiological condition is of paramount concern, but doing so in an environment that permits the movement of the immobilized subject in a variety of positions to maximize the success of placing the animal within the imaging plane of the imaging apparatus. Further complicating these procedures is the fact that some protocols necessitate that the embryos of pregnant animals be externalized from the abdomen to provide for improved imaging resolution.

To date, no device serves each of the needs outlined to enable the safe and effective delivery of anaesthesia to small animals, the physiological monitoring of the immobilized subject, the capacity for a range of motion, and the ability to successfully externalize embryos on a specialized table.

## SUMMARY

The imaging system of the present invention allows for productive imaging of small-animals. In one example, the imaging system can include a plurality of elongated rails, a scanhead assembly, and a small animal mount assembly. In another example, a needle injection assembly is also included in the imaging system.

The plurality of elongated rails can include a first rail, a second rail, and, if used, a third rail. Each rail has a proximal end, a spaced distal end, and a longitudinal axis. In one exemplary configuration, the proximal end of the first rail is positioned proximate a first edge of the second rail intermediate the proximal end and distal end of the second rail such that the longitudinal axis of the first rail is at an angle to the longitudinal axis of the second rail. In another exemplary example, the proximal end of the third rail is positioned proximate a second edge of the second rail intermediate the proximal end and distal end of the second rail such that the third rail and the first rails are on opposite sides of the second rail. In this example, the longitudinal axis of the third rail is substantially coaxial to the longitudinal axis of the first rail.

The scanhead assembly is selectively mounted onto the first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail. The small-animal mount assembly is selectively mounted onto the second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail. In one aspect, the needle injection assembly is selectively mounted onto the third rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail. Alternatively, the needle injection assembly is mounted onto the first rail, such that the second rail is positioned therebetween the needle injection assembly and the scanhead assembly.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the preferred embodiments of the invention will become more apparent in the following

3

detailed description in which reference is made to the appended drawings wherein:

FIG. 1 is a perspective view of one embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail and a small-animal mount assembly mounted onto a second rail.

FIG. 2 is a perspective view of an alternative embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail, a small-animal mount assembly mounted onto a second rail, and a needle injection assembly mounted onto a third rail.

FIG. 3 is a schematic view of the small-animal imaging system of FIG. 2.

FIG. 4 is a side view of the small-animal imaging system of FIG. 2.

FIG. 5 is a perspective view of a first or third rail of the present invention.

FIG. 6 is a perspective view of a movable stop.

FIG. 7 is an exploded view of the movable stop of FIG. 6.

FIG. 8 is a perspective view of an embodiment of the second rail of the present invention showing two spaced fixed stops.

FIG. 9 is a perspective view of the scanhead assembly mounted onto the first rail, showing a mount and a scanhead unit.

FIG. 10 is a perspective view of a base member of the scanhead assembly showing at least one carriage connected to the bottom of the base member.

FIG. 11 is a perspective view of an elongate upright member, a cantilever beam, and a scanhead orientation control mechanism of the scanhead assembly of FIG. 9.

FIG. 12 is an exploded view of the elongate upright member, the cantilever beam, and the scanhead orientation control mechanism shown in FIG. 11.

FIG. 13 is a perspective view of the small-animal mount assembly mounted onto the second rail.

FIG. 14 is a perspective view of the small-animal mount assembly of FIG. 13.

FIG. 15 is a top view of the small-animal mount assembly of FIG. 13.

FIG. 16 is a side view of the small-animal mount assembly of FIG. 13.

FIG. 17 is a side view of the small-animal mount assembly of FIG. 13.

FIG. 18 is a perspective view of a base member of a mount subassembly of the small-animal mount assembly shown in FIG. 13.

FIG. 19 is an exploded view of the base member shown in FIG. 18.

FIG. 20 is a perspective view of a planar platform of the mount subassembly.

FIG. 21 is a perspective view of a portion of a table orientation control mechanism of the mount subassembly.

FIG. 22 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

FIG. 23 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

FIG. 24 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

FIG. 25 is a top view of the housing of the orientation control mechanism of FIG. 24.

FIG. 26 is a perspective view of a portion of the orientation control mechanism.

4

FIG. 27 is a perspective view of a portion of the orientation control mechanism.

FIG. 28 is a perspective view of a portion of the orientation control mechanism showing portions of the housing removed.

FIG. 29 is a perspective view of a portion of the orientation control mechanism showing portions of the housing removed.

FIG. 30 is a perspective view of a portion of the orientation control mechanism operatively connected to a table member.

FIG. 31 is an exploded view of FIG. 6.

FIG. 32 is a side view of one embodiment of the needle injection assembly mounted onto the third rail, showing an injector subassembly and a carriage subassembly.

FIG. 33 is a perspective view of the needle injection assembly of FIG. 28.

FIG. 34 is a perspective view of a rotation adjustment mechanism and a height adjustment mechanism of the carriage subassembly.

FIG. 35 is an exploded view of the rotation adjustment mechanism and the height adjustment mechanism of FIG. 34.

FIG. 36 is a perspective view of a first lateral adjustment mechanism, a second lateral adjustment mechanism, a first tilt adjustment mechanism, and a second tilt adjustment of the carriage subassembly.

FIG. 37 is an exploded view of the first lateral adjustment mechanism, the second lateral adjustment mechanism, the first tilt adjustment mechanism, and the second tilt adjustment mechanism of FIG. 36.

FIG. 38 is a perspective view of a portion of the articulating armature subassembly showing the mount member.

FIG. 39 is a perspective view of a plurality of cooperative arm members of the articulating armature subassembly.

FIG. 40 is a partial cross-sectional view of the needle injection assembly.

FIG. 41 is a partial cross-sectional view of a portion of the injector unit.

FIG. 42 is a perspective view of an injector unit of the injector subassembly.

FIG. 43 is an exploded view of the injector unit of FIG. 42.

FIG. 44 is a perspective view of one embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail.

FIG. 45 is a perspective view of the scanhead assembly of FIG. 44 showing a scanhead articulation unit attached to a scanhead unit.

FIG. 46 is a perspective view of an alternative embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail, a small-animal mount assembly mounted onto a second rail, and a needle injection assembly mounted onto the first rail.

FIG. 47 is a perspective schematic view of the small-animal imaging system of FIG. 46 showing a scanhead articulation unit attached to a scanhead unit.

FIG. 48 is a semi-transparent layered perspective view of the second rail movable mounted to the first rail and the planar platform of the mount subassembly.

FIG. 49 is a partial semi-transparent layered perspective view of the height adjustment mechanism of the scanhead assembly.

FIG. 50 is a partial semi-transparent layered perspective view of the cantilever mount member of the scanhead assembly.

5

FIG. 51 is a partial bottom perspective view of the scanhead articulation unit of the present invention.

FIG. 52 is a partial cross-sectional view of the scanhead articulation unit.

FIG. 53 is a partial cross-sectional view of the scanhead articulation unit.

FIG. 54 is a top perspective view of a table member mounted onto a platform member.

FIG. 55 is a perspective view of the platform member mounted thereon a ball-joint lock assembly that is, in turn, mounted onto a housing containing a magnetic lock.

FIG. 56 is a semi-transparent layered bottom perspective view of the orientation control mechanism releasably mounted to the platform member of the present invention.

FIG. 57 is a partial bottom perspective view of the orientation control mechanism showing a bias element of the coarse height mechanism acting on the first housing that is partially housed within the second housing.

FIG. 58 is a partial semi-transparent top perspective view of the fine height mechanism of the orientation control mechanism.

FIG. 59 is a partial semi-transparent perspective view of the fine and coarse height mechanisms of the orientation control mechanism.

FIG. 60 is a partial semi-transparent perspective view of the ball-joint lock assembly of the orientation control mechanism mounted to a shoe member of a release mount assembly.

FIG. 61 is a partial semi-transparent perspective view of the release mount assembly mounted to the bottom face of the platform member.

FIG. 62 is a perspective view of a shoe member, a foot member, and a lock assembly of the release mount assembly.

FIG. 63 is a perspective view of a shoe member of FIG. 58.

FIG. 64 is a partial system view of the imaging system of the present invention, showing a needle injection assembly, a plunger control unit, and the orientation control mechanism of the present invention.

FIG. 65 is a partial perspective view of the needle injection assembly mounted thereon the first rail of the imaging system of the present invention.

FIG. 66 is a partial semi-transparent perspective view of the rotation adjustment mechanism and a portion of the first height adjustment mechanism of the carriage assembly.

FIG. 67 is a perspective view of a portion of the carriage assembly to which the injection unit is mounted.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be apparent to those skilled in the art. Thus the embodiments of this invention described and illustrated herein are not intended to be exhaustive or to limit the invention to the precise form disclosed. They are chosen to describe or to best explain the principles of the invention and its application and practical use to thereby enable others skilled in the art to best utilize the invention. As used in the specification and in the claims, "a," "an," and "the" can mean one or more, depending upon the context in which it is used. The preferred embodiment is now described with reference to the figures, in which like numbers indicate like parts throughout the figures.

6

Referring to FIG. 1, one embodiment of an integrated multi-rail imaging system 10 of the present invention is shown. The imaging system includes a plurality of elongated rails 30, a scanhead assembly 100 selectively mounted onto a first rail 32 of the plurality of elongated rails, and a small-animal mount assembly 200 selectively mounted onto a second rail 34 of the plurality of elongated rails. In an alternative embodiment shown in FIGS. 2-4, the imaging system 10 can also include a needle injection assembly 400 that is selectively mounted onto a third rail 36 of the plurality of elongated rails.

As noted above, and as shown in the figures, the plurality of elongated rails 30 includes the first rail 32, the second rail 34, and, if the needle injection assembly 400 is used, the third rail 36. Each rail has a proximal end 35, a spaced distal end 37, and has a longitudinal axis R1, R2, and R3. Each rail 30 can be connected to an elongate support plate 40 by welding or by conventional fasteners, such as, for example, screws, bolts, or the like. Each support plate can have at least one damper member 42, such as, for example, rubber feet, connected to and extending from the bottom of the support plates to help reduce vibrations. The scanhead assembly 100, the small-animal mount assembly 200 and the needle injection assembly 400 each has a base member 102, 202, 402 that is constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon their respective rails in a linear bi-directional manner, i.e., along the respective rail's longitudinal axis. As one will appreciate, each base member has at least one carriage 44 connected to the bottom of the base member that is adapted to slide on the respective rail. In one embodiment, each rail can also have a fixed stop 50 connected to the distal end of the rail to limit the movement of the base member mounted thereto. In an alternative embodiment, the second rail can have a pair of fixed stops 51 connected to the second rail and defining two fixed end points for bi-directional travel of the base member 202.

In use, an end edge 46 of the support plate 40 that is connected to the first rail 32 is connected to a side edge 48' of the support plate that is connected to the second rail 34. The proximal end 35 of the first rail 32 being positioned adjacent the second rail 34 and between the proximal and distal ends 35, 37 of the second rail. In this configuration, the longitudinal axis of the first rail is at an angle with respect to the longitudinal axis of the second rail. In one embodiment, the angle  $\gamma$  is about and between 150 to 30 degrees. In another embodiment, the angle  $\gamma$  is about and between 130 to 60 degrees. In yet another embodiment, the angle  $\gamma$  is about and between 110 to 70 degrees. In another embodiment, the angle  $\gamma$  is about and between 95 to 85 degrees.

If used, an end edge 46 of the base plate 40 that is connected the third rail 36 is connected to a side edge 48" of the base plate of the second rail 34 (opposite to the side edge to which the first rail 32 is connected). The proximal end 35 of the third rail 36 being positioned adjacent the second rail and between the proximal end and distal end of the second rail such that the third rail 36 opposes the first rail 32. In this example, the distal ends of the respective first and third rails extend away from each other and the longitudinal axis of the first and the third rails are substantially co-axial. Thus, the respective longitudinal axis R1, R2, and R3 are fixed in a relative orientation with respect to one another to provide a common coordinate system.

The imaging system 10 of the present invention can also include at least one movable stop 52. Each movable stop 52 is constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon their respective rails in the



linear bi-directional manner, i.e., along the respective rail's longitudinal axis. In one example, one movable stop **52** is mounted to each respective rail intermediate the respective base member **102**, **202**, **402** and the proximal end of the rail. In another example, one moveable stop is mounted to each of the first and third rails.

Each movable stop **52** also has a stop clamping mechanism **54** that can selectively fix the position of the moveable stop relative to the rail member. As one will appreciate, the operator of the system can readily adjust the position of the movable stops by releasing the stop clamping mechanism, moving the movable stop to the desired position, and clamping the movable stop to the rail at a desired position with the stop clamping mechanism. A portion of the base member **102**, **202**, **402** can be selectively and releasably secured to a portion of one respective movable stop.

In one example, the portion of the base member and the portion of the movable stop are magnetized with an attractive polarity such that, when brought into proximity to each other, the respective portions of the base member and the moveable stop are attracted to each other. In another example, a second portion of each base member and a portion of the fixed stop are also magnetized with an attractive polarity such that, when brought into proximity to each other, the second portion of the base member and the portion of the fixed stop are attracted to each other. Thus, in use, the base members can be selectively moved between the fixed stop and the moveable stop and can be releasably secured to the movable stop in the desired position. This allows one of the end points of travel of the base members to be selectively adjusted and allows the base members to be quickly moved away and brought back to the selected desired position, i.e., back to the selectable end point of travel.

In another embodiment, as shown in FIGS. **44-67**, the imaging system **10** has a plurality of elongated rails **1030**, comprising a first rail **1031** and a second rail **1032**. In this embodiment, the second rail is selectively mountable to the first rail and is selectively moveable in a linear bi-directional manner along the longitudinal axis **R1** of the first rail **1031**. The longitudinal axis **R2** of the second rail is positioned such that it is at an angle  $\alpha$  relative to the longitudinal axis of the first rail. In fact, in one aspect, the longitudinal axis of the second rail is substantially perpendicular to the longitudinal axis of the first rail. The second rail **1032** may have a base member **1002** which enables the second rail to be selectively mounted to the first rail.

In one aspect of this embodiment, the scanhead assembly **1100** has a mount **1110** having a scanhead assembly base member **1102**. The scanhead assembly base member is selectively mountable to the first rail **1031** and is selectively moveable in a bi-directional manner along the longitudinal axis **R1** of the first rail.

Additionally, in one aspect, the imaging system comprises a small-animal mount assembly **1200**. The small-animal mount assembly **1200** has a mount subassembly with a base member **1202** that is selectively mountable to the second rail. The mount subassembly base member **1202** is also selectively moveable in a bi-directional manner along the longitudinal axis of the second rail, thereby positioning the small-animal mount assembly **1200** in a desired position along the second rail **1032**.

As discussed in the previous embodiment, this embodiment of the imaging system **10** may also comprise a needle injection assembly **1400**. In this aspect, the needle injection assembly has a base member **1402** that is selectively mountable to the first rail **1031** such that the second rail **1032** is

positioned between the scanhead assembly **1100** and the injection assembly base member **1402**. As with the scanhead assembly base member, the injection assembly base member is selectively moveable in a bi-directional manner along the longitudinal axis **R1** of the first rail.

For ease of construction and manipulation, the rails **1030** of the imaging system can be of similar construction. In this aspect, the rails comprise a top surface **1036**, a first edge **1037** and an opposed second edge **1038**, where each edge is substantially parallel to the longitudinal axis of the rail, and a raised lip **1039**. In one aspect, the raised lip **1039** extends therefrom each edge of the rail, substantially perpendicular to the top surface **1036** of the rail.

The respective base members of the scanhead unit, the needle injection unit, and the second rail may also comprise a plurality of bearing members **1042** mounted along their bottom portion. These bearing members may be positioned such that they engage each of the raised lips **1039** of the first rail, thereby enabling the respective base member to slide thereon the first rail along its longitudinal axis **R1**. As one in the art can appreciate, at least one bearing member **1042** should engage the raised lip of the first edge **1037** of the rail and at least one should engage the second edge **1038** of the rail. However, multiple bearing members may engage each of the raised lips. In this aspect, each of the respective base members may also have a locking mechanism **1050**. One example of the locking mechanism **1050** comprises a threaded bore **1051** therethrough the base member. As one skilled in the art can appreciate, a complementarily threaded knob **1053** may be inserted into the bore **1051**, such that when the knob **1053** is rotated and the threaded portion of the knob is sufficiently inserted into the bore **1051**, the distal end of the threaded knob frictionally engages the underlying first rail.

In yet another aspect, the first rail may be selectively mountable to a planar member **1040**, which would substantially underlie at least a portion of the bottom of the first rail. The planar member **1040** may be equipped with at least one handle **1044**, whereby, in use, an operator could transport the imaging system merely by lifting the handle(s) **1044**. In this aspect, the imaging system becomes increasingly portable. Scanhead Assembly

Referring to the figures, the scanhead assembly **100** includes a mount **110** and a scanhead unit **130**. The mount **110** includes the base member **102**, an elongate upright member **112**, a cantilever beam **114**, and a scanhead unit orientation control mechanism **160**. The upright member **112** is connected to and extends substantially normal to the base member **102** (which is mounted as described above to the first rail). The cantilever beam **114** has a first end **116** and a spaced second end **118**. The second end **118** of the beam has a sleeve member **120** constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon the exterior surface **113** of the upright member **112** in a linear bi-directional manner, i.e., along a longitudinal axis of the upright member. The longitudinal axis of the beam **114** is co-planar to the longitudinal axis of the first rail **32**.

The sleeve member **120** of the beam also has a beam lock mechanism **122** for selectively mounting the sleeve member at a desired position. For example, in use, a handle **124** of the beam lock mechanism can be rotated to loosen the beam lock mechanism, the beam can be raised or lowered into the desired position, and the handle **124** of the beam lock mechanism **122** is rotated to selectively lock the beam into the desired position relative to the upright member **122**. In one example, the exterior surface **113** of the upright member **112** defines at least one longitudinally extending groove **115**

and the interior surface **121** of the sleeve member **120** has at least one male protrusion **123**. The male protrusion is sized and shaped for complementary receipt within one groove **115** of the upright member. In one example, the male protrusion **123** extends at least partially along the length of the interior surface **121** of the sleeve member.

In one example, the scanhead unit **130** is an ultrasonic scan head. As one will appreciate however, other scanhead units can be used, such as, for example, on MRI scanhead, a CT scanhead, and the like. The scanhead unit **130** is electrically coupled to an external computer **20** for processing of the images. The scanhead unit **130** is operatively connected to the beam **112** of the scanhead assembly **100** in selective orientation by the scanhead unit orientation control mechanism **160**. In one example, the scanhead unit orientation control mechanism comprises an angle control lock mechanism **162** and a ball joint lock mechanism **170**. A proximal end **164** of the angle control lock mechanism **162** is connected to the beam proximate the first end **116** of the beam. A fixed portion of the angle control lock mechanism extends downwardly away from the beam along a substantially vertical axis. A distal end **166** of the angle control lock mechanism is connected to a proximal end **172** of the ball joint lock mechanism **170** and is constructed and arranged for pivotal movement of the ball joint lock mechanism along an angle control lock plane defined by the co-planar longitudinal axis of the first rail and the beam. As one will appreciate, the angle control lock mechanism **160** can be moved between a locked position and an unlocked position.

A distal end **174** of the ball joint lock mechanism **170** is connected to the scanhead unit and is constructed and arranged for pivotal movement of the scanhead unit. As one will appreciate, the ball joint lock mechanism **170** allows the operative end **132** of the scanhead unit to be positioned at an angle with respect to the vertical axis of the angle control lock mechanism and with respect to the angle control lock plane. The ball joint lock mechanism **170** is moveable between a locked position and an unlocked position. When the ball joint lock mechanism **170** is locked at the desired angle, it will be appreciated that the operative end **132** of the scanhead unit **130** can be moved through an arc in a desired image plane by selectively unlocking the angle control lock mechanism **160** and moving the angle control lock mechanism along its fixed range of movement.

In another embodiment, as depicted in FIGS. **44-53** of the imaging system of the present invention, wherein the second rail **1032** is mounted thereon the first rail **1031** and all of the rails are of similar construction, the mount **1110** of the scanhead assembly **1100** has a base member **1102** that is selectively mountable onto the first rail **1031**. As discussed herein above, the base member **1102** may have a plurality of bearing members **1042** that slidably engage the raised lips of the first rail **1031**.

In this embodiment, the scanhead assembly comprises a third rail **1033** and a fourth rail **1034**. The third rail extends upwardly away from the scanhead assembly base member **1102**, while the fourth rail **1034** is selectively mounted thereon the third rail **1033** and is substantially perpendicular to it. The scanhead unit orientation control mechanism **160** is connected to a first end **1041** of the fourth rail.

In this aspect, a cantilever mount member **810** is mounted thereon the third rail such that it can move in a bi-directional manner along the longitudinal axis of the third rail. The fourth rail **1034** is slidably attached to the cantilever mount member **810** such that the fourth rail can move in a linear, bi-directional manner along its longitudinal axis **R4** with

respect to the cantilever mount member and, thus, with respect to the longitudinal axis of the third rail **1033**.

In one aspect, the scanhead assembly **1100** has a height adjustment mechanism **830** that comprises an upright column **840**, a gear housing **850**, a threaded rod member **860**, and the cantilever mount member **810**. The upright column **840** is mounted thereon the scanhead assembly base member **1102** such that it extends upwardly away from the base member and has an upright axis **C1**. It acts to raise the entire third rail **1033** a fixed distance from the scanhead assembly base member. The gear housing **850** is mounted thereon a distal end **842** of the upright column and one end of the third rail is mounted to the top of the gear housing such that it extends upwardly parallel to the upright axis **C1**. The third rail also comprises an end member **812** mounted at the distal end **814** of the third rail. The end member defines a cavity **815** for operative receipt of a bearing. The proximal end **862** of the threaded rod member is rotatably mounted to the gear housing and the distal end **864** of the threaded rod member **860** is rotatably mounted in the bearing in the end member such that the threaded rod is positioned substantially parallel to the longitudinal axis **R3** of the third rail. As is depicted in the figures, the proximal end of the rod member is housed within the gear housing and has a bevelled gear **852** mounted thereto. A crank member **854** is provided having an end disposed therein the gear housing that has a complimentary bevelled gear **856** mounted thereon. In use, rotation of the crank member **854** results in rotation of the threaded rod member **860** about its axis. As one will appreciate, the gear housing **850** may be mounted thereon the top of the scanhead assembly base member **1102**, omitting the upright column.

The cantilever mount member **810** is mounted to the third rail and defines a threaded bore **813** that is sized and shaped for complimentary engagement with the threaded surface of the rod member **860**. In use, when the crank member is rotated and the threaded rod member rotates, the cantilever mount member selectively moves in a bi-directional manner along the third rail. As may be seen in the figures, the cantilever mount member **810** may also comprise a plurality of bearing members **1042** disposed thereon the cantilever mount member which may slidably engage a portion of the raised lips **1039** extending from the edges of the third rail. To selectively secure the cantilever mount member, and thus the fourth rail, in position along the third rail, a rail lock assembly **816** is provided. In this aspect, a body member **818** is mounted to portions of the back face **811** of the cantilever mount member such that a portion of the body member overlies the back face **1043** of the third rail. The portion of the body member defines a threaded bore **820** sized and shaped for complementary receipt of a threaded knob **822**. In use, the cantilever mount member **810** is raised/lowered to the desired position and the knob is rotated such that the distal end **824** of the knob engages the back face **1043** of the third rail to frictionally lock the cantilever mount member into position relative to the third rail. Additionally, as mentioned herein above, the fourth rail **1034** is slidably mounted thereon the cantilever mount member. As can be seen in the figures, the cantilever mount member comprises a second set of bearing members **1042** disposed thereon the cantilever mount member which may slidably engage a portion of the raised lips extending from the edges of the fourth rail, the fourth rail being substantially perpendicular to the third rail. To selectively secure the fourth rail in position with respect to the cantilever mount member, and thus the third rail, another rail lock assembly **815** is provided. In this aspect, a body member **817** is mounted to

## 11

portions of the top surface of the cantilever mount member, opposite the other body member **818**, such that a portion of the body member **817** overlies the top surface **1036** of the fourth rail. Similarly, a portion of the body member defines a threaded bore **820'** sized and shaped for complementary receipt of a threaded knob **822'**. In use, the third rail is moved to the desired position and the knob **822'** is rotated such that the distal end of the knob engages the top surface **1036** of the fourth rail to frictionally lock the fourth rail into position relative to the cantilever member.

The scanhead unit orientation control mechanism **160** is connected to a portion of the first end **1041** of the fourth rail and a portion of the scanhead unit **1130**. As described herein above, the scanhead unit orientation control mechanism **160** is constructed and arranged to position the emitting end of the scanhead unit **130** in a desired image plane. In use, the scanhead unit **130** has transducer that travels within the scanhead in order to enable the scanhead unit to take an image slice in the image plane.

In one aspect, the scanhead assembly **1100** further comprises a scanhead articulation unit **900** selectively mounted therebetween the scanhead unit orientation control mechanism **160** and the scanhead unit **1130**. The scanhead articulation unit **900** is designed to articulate the scanhead unit **130** in a direction normal to the desired image plane, thereby enabling the scanhead unit to take multiple image slices in multiple image planes. When the multiple images are electronically combined, the resulting image has an apparent three-dimensional quality.

The scanhead articulation unit **900** comprises a motor mount **910**, a motor assembly **920**, a threaded rod **930**, and a saddle member **940**. The motor mount has a proximal end **912** that is mounted to the distal end **174** of the ball joint lock mechanism **170** of the scanhead unit orientation control mechanism **160**. A portion of the motor mount defines a bore **914**. Additionally, the motor assembly **920** is mounted thereon a portion of the motor mount. In one aspect, the motor assembly has a driven tube **922** which is co-axial with the bore **914** of the motor mount and has a threaded interior surface. As one can appreciate, the motor assembly can be a stepper motor or any other conventional motor, wherein the driven tube is the shaft of the motor. The threaded rod **930** is constructed and arranged to operatively engage the inner surface of the driven tube such that its longitudinal axis **T1** is substantially transverse to the desired image plane. In use, when the driven tube is rotated by the motor assembly, the threaded rod is driven in a bi-directional manner along its longitudinal axis.

The saddle member **940**, which has two opposed sides **942** and a floor **944** extending therebetween, is mounted thereon the threaded rod such that the ends **932** of the threaded rod rotatably engage the two opposed sides **942** of the saddle member. As one can appreciate, the sides of the saddle member may comprise conventional bearings for receipt of the ends of the threaded rod. The scanhead unit is mounted to and extending therefrom the bottom portion **946** of the floor **944** of the saddle such that movement of the threaded rod moves the saddle member that, in turn, moves the scanhead unit **130** about an axis that is parallel to the longitudinal axis **T1** of the threaded rod. Thus, movement of the threaded rod along its axis moves the image plane along a movement axis **M1** substantially parallel to the longitudinal axis of the threaded rod.

In one aspect, the distal end **174** of the ball joint lock mechanism **170** defines a quick release post (not shown) that comprises a longitudinal slot (not shown). In this aspect, the proximal end of the motor mount comprises a female quick

## 12

release mount. The quick release mount comprises a pin disposed on its interior portion sized and shaped for complementary engagement with the longitudinal slot of the quick release post. In other words, the two components form a key-way relationship. This relationship ensures that the scanhead articulation unit **900** is mounted in a position such that the movement of the scanhead unit **130** is substantially normal to the desired image plane. In this aspect, the bottom portion **946** of the floor **944** of the saddle is similarly equipped with a quick release mount, while the scanhead unit **130** is equipped with a quick release post.

In another aspect, the motor mount **910** further comprises an elongate beam member **970** attached to the distal end **916** of the motor mount. As depicted in the figures, the beam member **970** is positioned substantially transverse to the longitudinal axis of the motor mount and substantially parallel to the longitudinal axis **T1** of the threaded rod. The beam member **970** comprises a bearing surface **972** along its longitudinal axis. In one aspect, the saddle member **940** comprises a bearing member **948** attached to and extending therefrom a top portion **947** of the floor **944** of the saddle member. The bearing member **948** would operatively engage the bearing surface **972** of the beam member **970**, such that, in this aspect, the beam member and the bearing system acts to stabilize the movement of the scanhead unit **130** along the movement axis **M1**.

#### Small-Animal Mount Assembly

The small-animal mount assembly **200** of the present invention comprises a table subassembly **210** and a mount subassembly **260**. The table subassembly **210** comprises a table member **212**. The mount subassembly **260** comprises a base member **202**, which is mounted to the second rail **34** as described above, a planer platform **262**, and a table orientation control mechanism **280** selectively positioned onto a portion of an upper surface **264** of the platform **262**. The table orientation control mechanism **280** is constructed and arranged for adjusting the height, tilt and rotation of the operatively connected table member **212** relative to the upper surface **264** of the platform **262**.

In one example, an operator selectable plunger lock mechanism **206** is connected to the edge of the base member **202**. A portion of the plunger lock mechanism is constructed and arranged for selectively engaging a portion of a fixed stop **51** connected to the second rail. The plunger lock mechanism can comprise a spring mechanism for "locking" the plunger lock mechanism to the respective fixed stop until operator force is applied to the plunger lock mechanism **206**. In use, the operator draws the plunger lock mechanism upward to separate the plunger lock mechanism from the respective fixed stop. The base member **202** can then be moved along the longitudinal axis of the second rail until it is selectively lock to the other fixed stop. In this example, one fixed stop **51** is positioned proximate the distal end of the second rail and the other fixed stop **51** is positioned intermediate the proximal and distal ends of the second rail.

In one example, the platform **262** is movably connected to the base member **202** by a platform adjustment mechanism **270**. The platform **262** has a lower surface **266** that is opposed to the upper surface and defines a first axis **A1** parallel to the longitudinal axis of the second rail and a second axis **A2** normal to first axis. The platform can also have a raised edge **268** extending substantially about the periphery of the platform to help prevent the orientation control mechanism from falling from the upper surface **264** of the platform.

The platform adjustment mechanism **270** is constructed and arranged for moving the platform in a platform plane

## 13

defined by the respective first-axis and second-axis of the platform. A platform base **272** of the platform adjustment mechanism is connected to a portion of the top surface **204** of the base member and an adjustable armature **274** of the platform adjustment mechanism is connected to a portion of an edge of the platform **262**. In use, rotational movement of a first control knob **276** of the platform adjustment mechanism moves the platform bi-directionally relative to the base member along the first axis of the platform. In the same manner, rotational movement of a second control knob **278** of the platform adjustment mechanism moves the platform bi-directionally relative to the base member along the second axis of the platform. As one will appreciate movement of the platform **262** relative to the base member forward or rearward along the respective first or second axis depends upon the direction the first or second control knob is moved. In one aspect, the platform can be moved relative to the base member **202** between end points along each of its respective first and second axis less than and including about 100 mm. In another aspect, less than and including about 80 mm. In yet another aspect, less than and including about 60 mm. In another aspect, less than and including about 50 mm.

In this example, the lower surface **266** of the platform can rest on the top surface **204** of the base member **202**. Further, the upper and lower surfaces **264**, **266** of the platform and the top surface **204** of the base member are positioned in parallel planes. A coating or sheet of low-friction material such as, for example, Teflon™, can cover the lower surface **266** of the platform or the top surface **204** of the base member **202**. One skilled in the art will appreciate that other low-friction materials are contemplated. Thus, in use, the platform can be selectively moved in the first and second axis within the platform plane under the control of the platform adjustment mechanism **270**. The low-friction coating allows this motion to take place with minimal friction.

The orientation control mechanism **280** comprises a housing **282** having a top **284** and a bottom **286**. In use, the bottom of the housing is disposed onto and can be selectively slid along the upper surface **264** of the platform **262**. The upper surface of the platform can also be coated with low-friction material. This low-friction coating allows the operator to readily position the housing **282** of the orientation control mechanism onto a desired portion of the upper surface of the platform. The orientation control mechanism comprises a magnetic lock **600** that is housed within the housing. Upon movement of a magnet control knob **602**, which extends beyond the exterior of the housing, the magnetic lock **600** is movable from a retracted, non-engaged position, to an engaged position in which a magnet **604** is brought into attractive contact with the upper surface of the platform. As one will appreciate, when the magnetic lock is in the engaged position, the housing of the orientation control mechanism is fixed relative to the platform due to the attraction of the magnet and the platform. However, even if the magnetic lock **600** is in the engaged position, the housing can slide on the upper surface of the platform if sufficient force is exerted onto the housing or the connected table assembly.

The orientation control mechanism **280** can further comprise a coarse height mechanism **290**, a rotation control mechanism **310**, a fine height control mechanism **320**, a first tilt control mechanism **330**, and a second tilt control mechanism **340**. The coarse height mechanism is housed within the housing and is constructed and arranged for selective bi-directional movement of an upright shaft member **300** along an upright axis of the orientation control mechanism **280**. The upright axis is substantially normal to the longitudinal

## 14

axis of the second rail **34**. Thus, upon movement of a lever control **290** of the coarse height mechanism, the shaft member **300** can be raised or lowered as desired between a top, extended, position and a lowered, contracted, position. To accommodate the movement of the lever control, the housing defines an “L” shaped slot **294** in one side having an upright portion **296** and a longitudinally extending portion **298** proximate the top of the housing. In the lowered position, the lever control is in lower portion of the upright portion of the slot. In order to raise the top **301** of the shaft member **300** to its top position, the lever control **292** is lifted upward the extent of the upright portion of the slot **294** and is then slid into and seated within the longitudinally extending portion of the slot.

The shaft member **300** of the orientation control mechanism can be rotated about the upright axis about a bearing **312** positioned within the housing **282**. The rotation brake mechanism **310** is housed within the housing and is constructed and arranged for selectively engaging a brake surface **314** connected to the shaft member so that the shaft member can be fixed in a desired position about the upright axis. Thus, the shaft member can be rotated by applying a rotational force to the shaft such that the table member, which is operatively engaged to the shaft member, can be rotated about the upright axis until the table member is in the desired orientation. When the shaft member is positioned in the desired position, a brake knob **314**, which extends beyond the exterior of the housing, of the rotation brake mechanism **310** can be selectively activated to selectively fix the shaft member in the desired position relative to the upright axis.

A movable cap **322** is operatively connected to the shaft member and can be selectively moved by the fine height control mechanism **320**. The fine height control mechanism is constructed and arranged for selective bi-directional movement of the moveable cap relative to the top **301** of the shaft member **300** along the upright axis of the orientation control mechanism **280**. Thus, upon movement of a height control knob **324** of the fine height mechanism, the cap **322** can be raised or lowered as desired. In one aspect, the cap **322** can be moved relative to the top **301** of the shaft member between end points along the upright axis less than and including about 50 mm. In another aspect, less than and including about 30 mm. In yet another aspect, less than and including about 20 mm. In another aspect, less than and including about 10 mm.

The table member **212** defines a table plane that further defines an x-axis and an y-axis. One will appreciate that the x and y axis of the table plane form a common coordinate system. The first tilt control mechanism **330** is operatively connected to the cap **322** and is constructed and arranged for selectively adjusting and securing the tilt of the table member **212** relative to the y-axis of the table plane. The second tilt control mechanism **340** is operatively connected to a bottom surface **213** of the table member **212** and is constructed and arranged for selectively adjusting and securing the tilt of the table member relative to the x-axis of the table plane. A portion of the second tilt control mechanism **340** is mounted onto a top surface **332** of the first tilt control mechanism **330**.

In this configuration, the first and the second tilt control mechanisms **330**, **340** allow the table member **212** to be angled with respect to the respective y-axis and x-axis of the table plane. In one aspect, the angle is less than and including about 60 degrees (i.e.,  $\pm 30$  degrees). In another aspect, the angle is less than and including about 45 degrees (i.e.,  $\pm 22.5$  degrees). In yet another aspect, the angle is less

15

than and including about 30 degrees (i.e.,  $\pm 15$  degrees). Thus, in operation, selective manipulation of the controls of the mount subassembly 260 by the operator allows the table member 212 to be oriented in a desired table surface plane.

The table member 212 has a top surface 214 that is disposed in the table surface plane. The table subassembly 210 can also comprise a plurality of ECG electrode contact pads 220, at least one grid of electronic heating elements 230, and/or at least one thermocouple 240. In one aspect, the plurality of ECG contact pads is operatively attached to the top surface 214 of the table member. Each ECG contact pad senses an ECG signal within a portion of a small animal that is secured against the ECG contact pad. Each ECG contact pad 220 is spaced from an adjacent contact pad and can be positioned so that each one of the feet/paws of the small animal can be selectively positioned against one of the ECG contact pads. In one aspect, the plurality of ECG contact pads comprises four ECG contact pads that are positioned in a spaced "X" configuration so that the respective feet of the small animal can be positioned in a splayed position. Each ECG contact pad 220 generates an ECG signal 222 representative of the sensed ECG. The ECG signal can be transmitted through an A/D converter (not shown) to a control apparatus 250 on ECG signal line 224. This ECG signal can be transmitted through an isolated ECG amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

The grid of electronic heating elements 230 is disposed onto the top surface 214 of the table member 212 and is electrically coupled to the control apparatus 250. The temperature of the top surface 214 of the table member can be adjusted via the control apparatus so that a small animal's temperature can be maintained within a desired range when the small animal is positioned onto the top surface 214 of the table member. If used, the thermocouple 240 is connected to the top surface of the table member and can be positioned such that a portion of the small animal overlies the thermocouple when the small animal is secured to the top surface 214. In one example, the thermocouple is positioned near the center of the top surface 214 of the table member 212 and is spaced from the at least one grid of electronic heating elements 230. The thermocouple 240 generates a temperature signal 242 representative of the sensed temperature of the small animal proximate the thermocouple. The temperature signal 242 can be transmitted through an A/D converter (not shown) to the control apparatus 250 on temperature signal line 244. This temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

The table subassembly 210 can also comprise a rectal temperature probe 246. The rectal temperature probe generates an internal temperature signal 248 representative of the sensed internal temperature of the small animal with the rectum of the small animal the thermocouple. The internal temperature signal 248 can be transmitted through an A/D converter (not shown) to the control apparatus on temperature signal line 249. This internal temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

In one example, if external embryonic imaging is desired, the table subassembly 210 can further comprise a walled dish 360 and a dish support mechanism 370. The dish 360 has a peripheral wall 362 and defines an opening 364 in the bottom of the dish. The dish is formed of a substantially rigid material, such as, for example, a rigid plastic. A pliable

16

membrane 366 defining a slit 368 is connected to the opening to form a moisture proof connection. In one aspect, in a relaxed position, the slit in the membrane is closed and is moisture proof. In a stretched position, the slit in the membrane is open. The pliable membrane can be a rubber membrane. In another aspect, the slit 368 in the membrane 366 is open in both the relaxed and stretched positions.

The dish 360 can be selectively held in position relative to the top surface 214 of the table member 212 by selective actuation of a dish support mechanism 370. The dish support mechanism has an arm member 372 and a fastener 374. The arm member has an upper portion 376 that is constructed and arranged for selectively clamping onto a portion of the wall 262 of the dish. As one will appreciate, the dish 260 can be removed by removing knurled screw 378. The arm member 372 has a lower portion defining an elongate slot 379. The fastener 374 passes through the slot 379 and can selectively secure the lower portion of the arm member to an edge of the table member. In use, the position of an attached dish can be adjusted by loosening the fastener 374, adjusting the dish 360 into the desired position, and tightening the fastener 374 to secure the dish 260 in the desired position.

In certain externalized procedures, the small animal is secured to the top surface 214 of the table member and the dish 260 is disposed onto the small animal such that the pliable membrane 366 is in the stretched open position with the "open" slit forming a moisture proof seal between the small animal and the dish. In this aspect, embryos can be passed through the slit in the rubber membranes and can be imaged in the dish while still attached to the small animal.

The table subassembly 210 can also comprise a clamp member 380 secured to a portion of the top surface 214 of the table member. In one aspect, the clamp member 380 is constructed and arranged for grasping a portion of a conical small animal mask 382 that is shaped and sized for fit with the snout of the small animal. The mask 382 is connected to at least one anaesthetic line that is coupled to an external anaesthetic source, not shown. In an alternative aspect, the clamp member 380 can selectively grasp a portion of the at least one anaesthetic line.

Referring now to FIGS. 54-63, an alternative embodiment of the small-animal mount assembly 1200 of the present invention is illustrated. In this aspect, the small-animal mount assembly 1200 of the present invention includes a table subassembly 1210 and a mount subassembly 1240. The table subassembly 1210 comprises a table member 212 and a platform member 1212. In one aspect, the table member has a bottom surface 213 and defines a table plane and the platform member 1212 has a top face 1214 and an opposed bottom face 1213. The bottom surface 213 of the table member 212 is mounted thereon the top face 1214 of the platform member 1212.

The mount subassembly 1240 comprises a mount assembly base member 1202, which is mounted to the second rail 1032 as described above, a planar platform 1242, and a table orientation control mechanism 1260 selectively positioned onto a portion of an upper surface 1244 of the platform 1242. The table orientation control mechanism 1260 is constructed and arranged for adjusting the height, tilt and rotation of the operatively connected table member 212 relative to the upper surface 1244 of the platform 1242. The small-animal mount assembly can also comprise a release mount assembly 1330 that is constructed and arranged for releaseably mounting the platform member 1212 to the orientation control mechanism 1260.

In one aspect, an operator selectable plunger lock mechanism 1206 is mounted on the top surface of the mount

17

assembly base member **1202**. A distal portion of a plunger of the plunger lock mechanism is constructed and arranged for selectively engaging a portion of one position hole of the at least one position hole defined in the second rail. The plunger lock mechanism **1206** can include a spring mechanism for “locking” the plunger lock mechanism to the respective position hole until operator force is applied to the plunger lock mechanism **1206**. In use, the operator draws the plunger of the plunger lock mechanism upward to separate the plunger from the respective position hole. While holding the plunger “up,” the mount assembly base member **1202** can be moved along the longitudinal axis of the second rail until the plunger is close to the desired position. The plunger is then released and the mount assembly base member is moved fractionally until the distal end of the plunger seats into the selected position hole of the second rail. Further, the second rail can include a first end cap positioned at the distal end of the second rail and a second end cap positioned at the proximal end of the second rail. The end caps prevent the base member from sliding off of the ends of the second rail. Of course, in is contemplated that the end caps can be selectively removable so that the mount assembly base member **1202** can be selectively separated from the second rail as desired.

Similar to the aspect described above, the platform **1242** is movably connected to the mount assembly base member **1202** by a platform adjustment mechanism **1250**. The platform **1242** has a lower surface **1246** that is opposed to the upper surface and defines a first axis **A1** parallel to the longitudinal axis of the second rail and a second axis **A2** normal to first axis. The platform can also have a raised edge **1248** extending substantially about the periphery of the platform to help prevent the orientation control mechanism from falling from the upper surface **1244** of the platform.

The platform adjustment mechanism **1250** is constructed and arranged for moving the platform in a platform plane defined by the respective first-axis and second-axis of the platform. A platform base **1252** of the platform adjustment mechanism is connected to a portion of the top surface **1204** of the mount assembly base member and an adjustable nature **1254** of the platform adjustment mechanism is connected to a portion of an edge of the platform **1242**. In use, rotational movement of a first control knob **1256** of the platform adjustment mechanism moves the platform bidirectionally relative to the mount assembly base member along the first axis of the platform. In the same manner, rotational movement of a second control knob **1258** of the platform adjustment mechanism moves the platform bidirectionally relative to the mount assembly base member along the second axis of the platform. As one will appreciate movement of the platform **1242** relative to the mount assembly base member forward or rearward along the respective first or second axis depends upon the direction the first or second control knob is moved. In one aspect, the platform can be moved relative to the mount assembly base member **1202** between end points along each of its respective first and second axis less than and including about 100 mm. In another aspect, less than and including about 80 mm. In yet another aspect, less than and including about 60 mm. In another aspect, less than and including about 50 mm.

In this aspect, the lower surface **1246** of the platform can rest on the top surface **1204** of the mount assembly base member **1202**. Further, the upper and lower surfaces **1244**, **1246** of the platform and the top surface **1204** of the mount assembly base member are positioned in parallel planes. A coating or sheet of low-friction material such as, for example, Teflon™, can cover the lower surface **1246** of the

18

platform or the top surface **1204** of the mount assembly base member **1202**. One skilled in the art will appreciate that other low-friction materials are contemplated. Thus, in use, the platform can be selectively moved in the first and second axis within the platform plane under the control of the platform adjustment mechanism **1250**. The low-friction coating allows this motion to take place with minimal friction.

It is contemplated that the orientation control mechanism **1260** can comprise any combination of a magnetic lock **1600**, a tilt and rotation mechanism **1290**, a fine height mechanism **1300**, and a coarse height mechanism **1310**. In one aspect, and as one will appreciate, the bottom of the orientation control mechanism is disposed onto and can be selectively slid along the upper surface **1244** of the platform **1242**. The upper surface of the platform can also be coated with low-friction material. This low-friction coating allows the operator to readily position the housing of the orientation control mechanism onto a desired portion of the upper surface of the platform. The orientation control mechanism can comprise a magnetic lock **1600** that is housed within a bottom portion of a housing. Upon movement of a magnet control knob **1602**, which extends beyond the exterior of the housing, the magnetic lock **1600** is movable from a retracted, non-engaged position, to an engaged position in which a magnet **1604** is brought into attractive contact with the upper surface of the platform. As one will appreciate, when the magnetic lock is in the engaged position, the housing of the orientation control mechanism is fixed relative to the platform due to the attraction of the magnet and the platform. However, even if the magnetic lock **1600** is in the engaged position, the housing can slide on the upper surface of the platform if sufficient force is exerted onto the housing or the connected table assembly.

As noted above, the orientation control mechanism **1260** can further comprise a tilt and rotation mechanism **1290**, a fine height mechanism **1300**, and a coarse height mechanism **1310**. The tilt and rotation mechanism **1290** allows the table plane defined by the table member to be positioned at a desired orientation with respect to an upright axis, which extends generally along the longitudinal axis of the orientation control mechanism and is substantially normal to the longitudinal axis of the second rail. In one aspect, the tilt and rotation mechanism **1290** comprises a ball-joint lock assembly **1292** having a distal end **1294** and a proximal end **1296**. In one aspect, the table subassembly **1210** is mounted to the distal end of the ball-joint lock assembly. As discussed below, in one aspect, it is contemplated that the table subassembly is releaseably mounted. The ball-joint lock assembly has a friction lock member **1298** that allows the ball-joint lock assembly to move between a locked position, in which the table plane of the table member is fixed at a selected orientation relative to the upright axis, and an unlocked position, in which the table member is freely movable about the upright axis. It is contemplated that, in an intermediate position between the locked and unlocked positions, the table member can be moved into a desired position by exerting sufficient force on the table/platform member to overcome the friction lock of the ball-joint lock assembly.

In one aspect, the table plane of the table member further defines an x-axis and a y-axis that form a common coordinate system. As one will appreciate, the ball-joint lock assembly is constructed and arranged for selectively adjusting and securing the tilt of the table member at selected angles relative to the respective x and y axis of the table plane, which positions the table member in the desired

19

orientation. In this aspect, the selected angle of the respective x and y axis is less than and including about 60 degrees (i.e.,  $\pm 30$  degrees). In another aspect, the selected angle is less than and including about 45 degrees (i.e.,  $\pm 22.5$  degrees). In yet another aspect, the selected angle is less than and including about 30 degrees (i.e.,  $\pm 15$  degrees). Thus, in operation, selective manipulation of the ball-joint lock assembly by the operator allows the table member to be oriented in a desired table surface plane.

The fine height mechanism **1300** comprises a cap **1302**, an upright shaft member **1304**, a first housing **1306**, and a fine height control mechanism **1308**. The cap **1302** has a top surface **1303** to which, in one exemplified aspect, the proximal end **1296** of the ball-joint lock assembly **1292** is disposed. The cap is further connected to the upright shaft member **1304** that extends substantially co-axial to the longitudinal axis of the orientation control mechanism. The first housing **1306** is constructed and arranged for support and rotatable connection of the shaft member. In use, the upright shaft member is operatively engaged with the first housing such that the upright shaft member can be selectively rotated about the upright axis. The fine height control mechanism is constructed and arranged for selective bidirectional movement of the distal end of the upright shaft, with its attached cap, along the upright axis relative to a top of the first housing. In use, clockwise or counter-clockwise rotation of the fine height control mechanism **1308** allows the cap **1302** to be raised/lowered to the desired height. Thus, upon movement of a height control wheel **1309** of the fine height control mechanism **1308**, the cap can be raised or lowered as desired. In one embodiment, the cap can be moved relative to the top of the first housing member between end points along the upright axis less than and including about 50 mm. In another aspect, less than and including about 30 mm. In yet another aspect, less than and including about 20 mm. In another aspect, less than and including about 10 mm.

The coarse height mechanism **1310** is housed within a second housing **1312** and is constructed and arranged for selective bi-directional movement of the first housing **1306** relative to the second housing **1312** along the upright axis of the orientation control mechanism **1260**. At least a portion of the first housing is moveably housed within an upper portion of a defined interior volume of the second housing. Further, the coarse height mechanism **1310** comprises a bias element, such as a spring, that is housed within a lower portion of the defined interior volume of the second housing. In one aspect, the magnetic lock **1600** is disposed within the interior volume of the second housing and is positioned at the bottom of the second housing. In this aspect, the bias element is positioned intermediate the magnetic lock and the first housing. The first housing can have a groove **1307** defined within a portion of the exterior surface of the first housing. The groove **1307** extends generally parallel to the upright axis and is sized and shaped to cooperate with a male protrusion **1303** defined in an interior surface of the interior volume of the second housing. The cooperating groove and male protrusions of the respective first and second housing allow for relative bidirectional movement of the first housing with respect to the second housing to occur without relative rotation of the first housing with respect to the second housing.

Thus, upon movement of a lever control **1318** of the coarse height control mechanism, the first housing **1306** can be, relative to the second housing **1312**, raised or lowered as desired between a top, extended, position and a lowered, contracted, position. To accommodate the movement of the

20

lever control **1318**, the housing defines a shaped slot **1320** in one side having an upright portion **1322**, a lower longitudinally extending portion **1324** proximate the bottom of the second housing, and an upper longitudinally extending portion **1326** proximate the top of the second housing. In the lowered position, the lever control **1318** is in the lower longitudinally extending portion proximate the bottom of the second housing and the bias element **1314** is in its most compressed position. In order to raise the first housing to its top position relative to the second housing, the lever control **1318** is lifted upward the extent of the upright portion of the slot **1322** and is then slid into and seated within the upper longitudinally extending portion of the slot proximate the top of the second housing. The bias element **1314** acts against a bottom portion of the first housing such that the first housing is urged toward a top portion of the second housing and toward its top position as the lever control is positioned in the upper portions of the defined slot.

In one aspect, the release mount assembly **1330** of the small-animal mount assembly comprises a shoe member **1340**, a foot member **1350** and a lock assembly **1360**. In one aspect, the shoe member defines a shaped trough **1342**. The trough has a pair of opposing guide edges **1343** and a back edge **1344** extending therebetween respective ends of the opposing guide edges. A portion of the back edge of the trough forms an angled flange surface **1346** that extended outward at an angle to overlie a portion of the interior of the trough. The foot member **1350** is sized and shaped for complementary disposition therein a portion of the trough of the shoe member. In one aspect, the foot member **1350** had a first bevelled edge **1352** and a second opposed bevelled edge **1354**. The first bevelled edge **1352** being sized and shaped for complementary engagement with the angled flange surface **1346** of the shoe member.

In one aspect, the shoe member **1340** is connected to a distal portion of the orientation control mechanism (such as, in one aspect, the distal end of the ball-joint lock assembly member) such that the defined trough faces outward and the back surface of the foot member **1350** is connected to the bottom face of the platform member. In an alternative aspect, if the ball-joint lock assembly is not a part of the orientation control mechanism, the shoe member can be connected to the top surface of the cap of the coarse height mechanism.

The lock assembly **1360** comprises a lock lever **1362** that is rotatably mounted to the shoe member **1340**. The lock lever has an eccentrically shaped edge surface **1364**, a portion of which has a bevelled cross-sectional shape **1366**. The lock lever **1362** being movable between a clamped position and an unclamped position. In the clamped position, the bevelled portion **1366** of the edge surface of the lock lever engages a portion of the second bevelled edge **1354** of the foot member and acts to force a portion of first bevelled edge **1352** of the foot member into a locked position with a portion of the angled flange surface **1346** of the shoe member. Thus, in one aspect, the flange surface of the shoe member is forced into complementary engagement with the first bevelled edge of the foot member and the bevelled edge of the lock lever is forced into complementary engagement with the second bevelled edge when the lock lever is positioned in the clamped position. In the unclamped position, as one will appreciate, the foot member can be selectively removed from the trough of the shoe member. It will be appreciated that it is contemplated that the foot member can be mounted on the distal portion of the orientation control mechanism and, in this aspect, the shoe member can be mounted to the bottom face of the platform member.

## 21

In one aspect, the platform has at least one leg mounted to and extending from the bottom face of the platform member. Each leg **1380** has a predetermined height that is less than a height of the foot member.

As noted above, the table member **212** has a top surface **214** that is disposed in the table surface plane. The table subassembly **210** can also comprise a plurality of ECG electrode contact pads **220**, at least one grid of electronic heating elements **230**, and/or at least one thermocouple **240**. In one aspect, the plurality of ECG contact pads is operatively attached to the top surface **214** of the table member. Each ECG contact pad senses an ECG signal within a portion of a small animal that is secured against the ECG contact pad. Each ECG contact pad **220** is spaced from an adjacent contact pad and can be positioned so that each one of the feet/paws of the small animal can be selectively positioned against one of the ECG contact pads. In one aspect, the plurality of ECG contact pads comprises four ECG contact pads that are positioned in a spaced "X" configuration so that the respective feet of the small animal can be positioned in a splayed position. Each ECG contact pad **220** generates an ECG signal **222** representative of the sensed ECG. The ECG signal can be transmitted through an A/D converter (not shown) to a control apparatus **250** on ECG signal line **224**. This ECG signal can be transmitted through an isolated ECG amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

The grid of electronic heating elements **230** is disposed onto the top surface **214** of the table member **212** and is electrically coupled to the control apparatus **250**. The temperature of the top surface **214** of the table member can be adjusted via the control apparatus so that a small animal's temperature can be maintained within a desired range when the small animal is positioned onto the top surface **214** of the table member.

If used, the thermocouple **240** is connected to the top surface of the table member and can be positioned such that a portion of the small animal overlies the thermocouple when the small animal is secured to the top surface **214**. In one aspect, the thermocouple is positioned near the center of the top surface **214** of the table member **212** and is spaced from the at least one grid of electronic heating elements **230**. The thermocouple **240** generates a temperature signal **242** representative of the sensed temperature of the small animal proximate the thermocouple. The temperature signal **242** can be transmitted through an A/D converter (not shown) to the control apparatus **250** on temperature signal line **244**. This temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

The table subassembly **210** can also comprise a rectal temperature probe **246**. The rectal temperature probe generates an internal temperature signal **248** representative of the sensed internal temperature of the small animal with the rectum of the small animal the thermocouple. The internal temperature signal **248** can be transmitted through an A/D converter (not shown) to the control apparatus on temperature signal line **249**. This internal temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

In one aspect, if external embryonic imaging is desired, the table subassembly **210** can comprise a walled dish **360** and a dish support mechanism **370**. The dish **360** has a peripheral wall **362** and defines an opening **364** in the

## 22

bottom of the dish. The dish is formed of a substantially rigid material, such as, for example, a rigid plastic. A pliable membrane **366** defining a slit **368** is connected to the opening to form a moisture proof connection. In one aspect, in a relaxed position, the slit in the membrane is closed and is moisture proof. In a stretched position, the slit in the membrane is open. The pliable membrane can be a rubber membrane. In another aspect, the slit **368** in the membrane **366** is open in both the relaxed and stretched positions.

The dish **360** can be selectively held in position relative to the top surface **214** of the table member **212** by selective actuation of a dish support mechanism **370**. The dish support mechanism has an arm member **372** and a fastener **374**. The arm member has an upper portion **376** that is constructed and arranged for selectively clamping onto a portion of the wall **262** of the dish. As one will appreciate, the dish **260** can be removed by removing knurled screw **378**. The arm member **372** has a lower portion defining an elongate slot **379**. The fastener **374** passes through the slot **379** and can selectively secure the lower portion of the arm member to an edge of the platform member. In use, the position of an attached dish can be adjusted by loosening the fastener **374**, adjusting the dish **360** into the desired position, and tightening the fastener **374** to secure the dish **260** in the desired position.

In certain externalized procedures, the small animal is secured to the top surface **214** of the table member and the dish **260** is disposed onto the small animal such that the pliable membrane **366** is in the stretched open position with the "open" slit forming a moisture proof seal between the small animal and the dish. In this example, embryos can be passed through the slit in the rubber membranes and can be imaged in the dish while still attached to the small animal.

The table subassembly **210** can also comprise a clamp member **380** secured to a portion of the top surface **214** of the table member. In an alternative aspect, the clamp member is connected to a portion of the edge of the platform member. In one aspect, the clamp member **380** is constructed and arranged for grasping a portion of a conical small animal mask **382** that is shaped and sized for fit with the snout of the small animal. The mask **382** is connected to at least one anaesthetic line that is coupled to an external anaesthetic source, not shown. In an alternative aspect, the clamp member **380** can selectively grasp a portion of the at least one anaesthetic line.

#### Needle Injection Assembly

Referring now to FIGS. **32-43**, one embodiment of the needle injection assembly **400** is shown. The needle injection assembly is constructed and arranged for operator control of a needle's insertion point, insertion depth, and angle of penetration. The needle injection assembly **400** further can be constructed and arranged for controlling a needle plunger **433** of the needle **432**.

In one example, the needle injection assembly **400** includes the base member **402** (which is connected to the third rail **36** as described above), an injector subassembly **420**, and a carriage subassembly **450**. The injector subassembly **420** includes an injector unit **430** that has an elongated needle **432** operatively mounted therein. The needle **432** has a longitudinal length and a distal end **434**. The carriage subassembly **450** is connected to the base member **402** and provides controls for setting the needle's insertion point in the small animal in a desired plane, which is typically the same plane as the scanhead unit is set up to image, i.e., the desired image plane. The carriage subassembly **450** also provides controls for pivoting the needle **432** so that the operator can set a desired angle of penetration to the needle's insertion point in the small animal. The carriage



23

subassembly 450 can include a rotation adjustment mechanism 460, a height adjustment mechanism 470, a first lateral adjustment mechanism 480, a second lateral adjustment mechanism 490, a first tilt adjustment mechanism 500, a second tilt adjustment mechanism 510, and an articulating armature subassembly 530.

The rotation adjustment mechanism 460 is constructed and arranged for rotating portions of the carriage subassembly mounted thereon about an upright axis. In one example, the rotation adjustment mechanism includes a housing 462 that is connected to the top surface 404 of the base member 402. The rotation adjustment mechanism 460 further includes a conventional bearing 464 mounted within the housing that connects to and supports a frame member 465. The frame member 465 has a base 467 that is operatively connected to the bearing of the rotation adjustment mechanism. As one will appreciate, the frame member 465 can rotate about an upright axis extending normal to the longitudinal axis of the third rail and through the center of the bearing. The rotation adjustment mechanism 460 can include a rotation lock knob 466 for selectively locking the rotation of the frame member so that the amount of rotation of the frame member about the upright axis is limited. The rotation adjustment mechanism can also include a fine rotation adjustment control knob 468 that allows the operator to rotate the frame member through a limited angle about the upright axis after the rotation lock knob has been engaged. In one embodiment the limited angle is about and between 10 degrees (+/-5 degrees). In another embodiment, the angle is about and between 8 degrees (+/-4 degrees). In yet another embodiment, the angle is about and between 6 degrees (+/-3 degrees).

The height adjustment mechanism 470 is operatively connected to the frame member 465 and is constructed and arranged for raising portions of the carriage subassembly supported thereon along an upright axis. The height adjustment mechanism includes a platform 472 that can be selectively moved along an upright axis parallel to the upright axis of the rotation adjustment mechanism 460 between a top fixed end point and a bottom fixed end point. In use, rotation of the height adjustment knob 474 of the height adjustment mechanism moves the platform of the height adjustment mechanism bi-directionally relative to the base 467 of the frame member along the upright axis. As one will appreciate, movement of the platform 472 upward or downward along the upright axis depends upon the direction the height adjustment knob 474 is moved. In one embodiment, the platform 474 of the height adjustment mechanism can be moved about a center point between fixed end points about and between +/-25 mm. In another embodiment, about and between +/-18 degrees. In another example, about and between +/-13 degrees.

The first lateral adjustment mechanism 480 is connected to and is mounted onto the top surface 476 of the platform 472. The second lateral adjustment mechanism 490 is connected to and mounts thereon a selectively movable top surface 482 of the first lateral adjustment mechanism 480. The first tilt adjustment mechanism 500 is connected to and mounts thereon a selectively movable top surface 492 of the second lateral adjustment mechanism 490. Similarly, the second tilt adjustment mechanism 510 is connected to and is mounted onto a selectively movable top surface 502 of the first tilt adjustment mechanism 500. The articulating armature subassembly 520 is operatively connected to a selectively movable top surface 512 of the second tilt adjustment mechanism 510.

24

The first lateral adjustment mechanism 480 is constructed and arranged for moving the top surface 482 of the first lateral adjustment mechanism relative to the platform 472 and parallel to an x-axis defined by the platform. This allows the top surface 482 of the first lateral adjustment mechanism 480 to shift toward or away from the proximal end of the third rail 36. In use, rotation of a first lateral adjustment knob 484 moves the top surface 482 of the first lateral adjustment mechanism 480 bi-directionally relative to the platform. Similarly, the second lateral adjustment mechanism 490 is constructed and arranged for moving the top surface 492 of the second lateral adjustment mechanism relative to the top surface 482 of the first lateral adjustment mechanism 480 and parallel to a y-axis defined by the platform (which is normal to the defined x-axis). This allows the top surface 492 of the second lateral adjustment mechanism to shift toward or away from the respective side edges of the third rail 36. In use, rotation of a second lateral adjustment knob 494 moves the top surface 492 of the second lateral adjustment mechanism bi-directionally relative to the top surface 482 of the first lateral adjustment mechanism. As one will appreciate, in another example, the second lateral adjustment mechanism 490 can be connected to and mounted onto the top surface 476 of the platform 472 and the first lateral adjustment mechanism 480 can then be connected to and mounted thereon the selectively movable top surface 492 of the second lateral adjustment mechanism 490.

The articulating armature subassembly 520 has a mount member 522 that is, in one example, connected to the top surface 512 of the second tilt adjustment mechanism 510. The mount member 522 of the articulating armature subassembly defines a mount plane that further defines an x-axis and a y-axis. One will appreciate that the x and y axis of the mount plane form a common coordinate system. In one example, the first tilt adjustment mechanism 500 is operatively connected to the top surface 492 of the second lateral adjustment mechanism 490 and is constructed and arranged for selectively adjusting and securing the tilt of the mount member 522 relative to and about the y-axis of the mount member. The second tilt adjustment mechanism 510 is operatively connected to the top surface 502 of the first tilt mechanism 500 and is constructed and arranged for selectively adjusting and securing the tilt of the mount member 522 relative to the x-axis of the mount member.

In this configuration, the first and the second tilt adjustment mechanisms 500, 510 allow the mount member 522 to be angled with respect to the respective y-axis and x-axis of the mount member. In one embodiment, the angle is less than and including about 40 degrees (i.e., +/-20 degrees). In another embodiment, the angle is less than and including about 20 degrees (i.e., +/-10 degrees). In yet another embodiment, the angle is less than and including about 10 degrees (i.e., +/-5 degrees).

One will appreciate that, in another example, the second tilt adjustment mechanism 510 can be connected to and mounted thereon a selectively movable top surface of the uppermost of the first or second lateral adjustment mechanisms. In this example, the first tilt adjustment mechanism 500 is connected to and is mounted onto the selectively movable top surface 512 of the second tilt adjustment mechanism 510. The mount member of the articulating armature subassembly 520 would be operatively connected to the selectively movable top surface 502 of the first tilt adjustment mechanism.

The articulating armature assembly 520 includes a plurality of cooperative arm members 530 that are operatively connected to the mount member and can be moved by

25

selective actuation of an armature control mechanism 524. As one will appreciate, selective manipulation of the rotation adjustment mechanism 460, the height adjustment mechanism 470, the first lateral adjustment mechanism 480, the second lateral adjustment mechanism 490, the first tilt adjustment mechanism 500, and/or the second tilt adjustment mechanism 510 allows the mount member 522 of the articulating armature assembly to be positioned into a desired mount plane defined by a plane extending through the mount member. The injector unit 430 of the injector subassembly 420 is operatively mounted within a seat 532 positioned at a distal portion 534 of the plurality of cooperative arm members such that the distal end 434 of the needle 432 extends beyond the plurality of cooperative arm members. As one will appreciate, the injector unit 430 is positioned in a needle plane that is normal to the mount plane of the mount member 522.

The articulating armature assembly 520 is constructed and arranged for rotating the injector unit 430 about the distal end 434 of the needle in a desired needle plane that is normal to the desired mount plane. In operation, the desired needle plane is substantially coplanar to the desired image plane. As an armature control knob 526 is selectively rotated, the injector unit is between a first fixed end point in which the needle 432 is angled at a lower angle of penetration  $\theta$  relative to an upright axis to a second fixed end point in which the needle is angled at a higher angle of penetration  $\theta$  relative to the upright axis. Thus, the operator can selective set the exact insertion point of the needle and, via manipulation of the control of the articulating armature assembly, can select, within the desired needle plane, a desired angle of penetration  $\theta$  of the needle into the subject small animal. The articulating armature assembly 520 also includes a position brake mechanism 540 that can be selectively engaged to fix the plurality of cooperative arm members is a desired position. By "fixing" the plurality of cooperative arm members is the desired position, the operator can "fix" the desired angle of penetration  $\theta$  of the needle. By tightening knob 542 onto a portion of the mount member, the plurality of cooperative arm members can be selectively "locked" into position.

The injector subassembly 420 includes the injector unit 430 mounted thereon the seat 532 of the articulating armature assembly. In one example, the injector unit 430 includes a plunger 433, a barrel 436, and the elongate needle 432. The plunger 433 is movable within a defined chamber 437 of the barrel 436. A bore of the needle 432 is in communication with the chamber of the barrel. In use, the plunger 433 can be manually moved in a conventional manner to inject a desired amount of material into the subject small animal or to draw material thereinto the chamber of the barrel. In another example, the injector unit 430 also includes a conventional actuator 440 that is operatively coupled to the plunger 433. In this example, the actuator 440 is also electrically coupled to a plunger control unit 442. The user can actuate controls on the plunger control unit 442 to retract or extend the plunger of the injector unit a desired amount.

The injector subassembly further comprises a needle insertion mechanism 540 constructed and arranged for controlling the extension and the retraction of the injector unit 430 relative to the seat 532 of the plurality of cooperative arm members 530. In use, rotation of a needle insertion control knob 542 of the needle insertion mechanism moves the injector unit 430, and the attached needle, bi-directionally along the seat and along longitudinal axis of the needle 432. As one will appreciate insertion or retraction movement

26

of the injector unit and the attached needle depends upon the direction the needle insertion control knob 542 is moved.

Referring now to FIGS. 64-67, an alternative embodiment of the needle injection assembly 1400 is shown. As noted above, the needle injection assembly is constructed and arranged for operator control of a needle's insertion point, insertion depth, and angle of penetration. In one aspect, the needle injection assembly 1400 further can be constructed and arranged for controlling a needle plunger 433 of the needle 432.

In one aspect, the needle injection assembly 1400 comprises an injection assembly base member 1402 (which is connected to the first rail as described above), an injector subassembly 420, and a carriage subassembly 1450. The injector subassembly 420 comprises an injector unit 430 that has an elongated needle 432 operatively mounted therein. The needle 432 has a longitudinal length and a distal end 434. The carriage subassembly 1450 is connected to the injection assembly base member 1402 and provides controls for setting the needle's insertion point in the small animal in a desired plane, which is typically the same plane as the scanhead unit is set up to image, i.e., the desired image plane. The carriage subassembly 1450 also provides controls for orienting the needle 432 so that the operator can set a desired angle of penetration to the needle's insertion point in the small animal. The carriage subassembly 1450 can comprise a rotation adjustment mechanism 1460, a first height adjustment mechanism 1470, an injection angle adjustment mechanism 1490, a second height adjustment mechanism 1500, and a lateral adjustment mechanism 1490.

The carriage subassembly 1450 comprises a fifth rail 1035. The rotation adjustment mechanism 1460 is constructed and arranged for rotating the fifth rail 1035 about an upright axis extending substantially transverse to the injection assembly base member 1402 and that is substantially parallel to the longitudinal axis of the fifth rail. In one aspect, the rotation adjustment mechanism comprises a housing 1462 that is connected to the top surface 1404 of the injection assembly base member 1402. The rotation adjustment mechanism further comprises a conventional bearing mounted within the housing that connects to and supports a frame member 1465. The frame member has a base that is operatively connected to the bearing of the rotation adjustment mechanism. As one will appreciate, the frame member can rotate about the upright axis. The rotation adjustment mechanism 1460 can comprise a rotation lock knob 1466 for selectively locking the rotation of the frame member so that the amount of rotation of the frame member about the upright axis is limited. The rotation adjustment mechanism can also comprise at least one preset position, such as, for example, a preset position substantially co-axial to the longitudinal axis of the first rail and a preset position substantially transverse to the longitudinal axis of the first rail.

The first height adjustment mechanism 1470 is operatively connected to the frame member 1465 and is constructed and arranged for raising portions of the carriage subassembly 1450 supported thereon along an upright axis. The first height adjustment mechanism comprises a housing 1472, a threaded rod member 1474, and an injection assembly mount member 1476. The first height adjustment housing 1472 is mounted thereon the frame member. One end of the fifth rail is mounted to the first height adjustment housing such that it extends from the top of the housing parallel to the upright axis. The first height adjustment mechanism also comprises an end member 1478 mounted at the distal end of the fifth rail. The end member defines a cavity for operative

receipt of a bearing. The proximal end of the threaded rod member is rotatably mounted to the first height adjustment housing and the distal end of the threaded rod is rotatably mounted in the bearing in the end member such that the threaded rod is positioned substantially parallel to the longitudinal axis of the fifth rail. As shown in the figures, the proximal end of the rod member is housed within the first height adjustment housing and has a bevelled gear attached thereto. A crank member **1471** is provided having an end disposed therein the height adjustment housing that has a complementary bevelled gear mounted thereon. In use, rotation of the crank member results in a rotation of the threaded rod member about its axis. As one will appreciate, and as shown, bearings can be provided on the threaded rod member and the crank member.

The injection assembly mount member **1476** is mounted to the fifth rail and defines a threaded bore **1478** that is sized and shaped for complementary engagement with the threaded surface of the threaded rod member **1474**. In use, when the crank member **1471** is rotated and the threaded rod member rotates, the injection assembly mount member **1476** selectively moves bi-directionally relative to the top of the housing along the longitudinal axis of the fifth rail. As one will appreciate, upward or downward movement of the injection assembly mount member along the threaded rod member depends upon the direction the crank member is moved.

To selectively secure the injection assembly mount member **1476** in a desired position, a rail lock assembly **1480** is provided. In this aspect, the rail lock assembly **1480** comprises a body member **1482** that is mounted to portions of the back face **1479** of the injection assembly mount member such that a portion of the body member overlies the back face of the fifth rail. The portion of the body member defines a threaded bore **1484** sized and shaped for complementary receipt of a threaded knob **1486**. In use, the injection assembly mount member **1476** is raised/lowered to the desired position as described above and the threaded knob **1486** is rotated such that a distal end of the knob **1486** frictionally engages the back face of the fifth rail to frictionally lock the injection assembly mount member into position relative to the fifth rail.

In one aspect, the injection angle adjustment mechanism **1490** is connected to and is mounted onto a top surface **1473** of the injection assembly mount member **1476**. The second height adjustment mechanism **1500** is connected to and mounts thereon a mount surface **1492** of a selectively movable member **1494** of the injection angle adjustment mechanism **1490**. The lateral adjustment mechanism **1510** is connected to and mounts thereon a mount surface **1502** of a selectively movable member **1504** of the second height adjustment mechanism **1500**. The injector subassembly **420** is operatively connected to and mounts thereon a mount surface **1512** of a selectively movable mount member **1514** of the lateral adjustment mechanism **1510**.

The injection angle adjustment mechanism **1490** is constructed and arranged for rotating a member **1494** of the injection angle adjustment mechanism relative to the top surface **1473** of the injection assembly mount member. This allows the mount surface **1492** of the injection angle adjustment mechanism to be rotated about an axis substantially transverse to the longitudinal axis of the fifth rail. In use, rotation of an injection angle adjustment knob **1496** rotates the movable member **1494** of the injection angle adjustment mechanism relative to the top surface **1473** of the injection assembly mount member.

The second height adjustment mechanism **1500** is constructed and arranged for moving a member **1504** of the second height adjustment mechanism relative to the mount surface **1492** of the movable member **1494** of the injection angle adjustment mechanism along an axis substantially parallel to a rail plane that bisects the longitudinal axis of the fifth rail. This allows the mount surface of the second height adjustment mechanism to shift upwards or downwards in a plane substantially parallel to a rail plane. In use, rotation of a height adjustment knob **1506** moves the movable member **1504** of the height adjustment mechanism bi-directionally along its movement axis relative to the mount surface **1492** of the lateral adjustment mechanism.

Similarly, the lateral adjustment mechanism **1510** is constructed and arranged for moving the mount surface **1512** of the lateral adjustment mechanism relative to the mount surface **1502** of the movable member **1504** of the second height adjustment mechanism along an axis that is substantially normal to the rail plane of the fifth rail. This allows the mount surface **1512** of the lateral adjustment mechanism to shift toward or away from the rail plane of the fifth rail. In use, rotation of a lateral adjustment knob **1516** moves the movable member **1514** of the lateral adjustment mechanism bi-directionally along its movement axis relative to the mount surface of the height adjustment mechanism.

As one will appreciate, in another aspect, the lateral adjustment mechanism **1510** can be connected to and mounted onto the top surface **1473** of the injection assembly mount member and the second height adjustment mechanism **1500** can then be connected to and mounted thereon the mount surface **1512** of the selectively movable member **1514** of the lateral adjustment mechanism.

As one will appreciate, selective manipulation of the rotation adjustment mechanism **1460**, the first height adjustment mechanism **1470**, the injection angle adjustment mechanism **1490**, the second height adjustment mechanism **1500**, and the lateral adjustment mechanism **1510** allows the mount member **1504** of the lateral adjustment mechanism to be positioned into a desired mount plane defined by a plane extending through the mount member. The injector unit **439** of the injector subassembly **420** is operatively mounted to the mount member within a seat **532** positioned on the mount member of the lateral adjustment mechanism such that the distal end **434** of the needle **432** extends outwardly from in a desired needle plane.

In operation, the desired needle plane is substantially coplanar to the desired image plane. Thus, the operator can selective set the exact insertion point of the needle and, via manipulation of the controls of the respective adjustment mechanisms, can select, within the desired needle plane, a desired angle of penetration  $\theta$  of the needle into the subject small animal.

As noted above, the injector subassembly **420** includes the injector unit **430** mounted thereon the seat **532** of the articulating armature assembly. In one example, the injector unit **430** includes a plunger **433**, a barrel **436**, and the elongate needle **432**. The plunger **433** is movable within a defined chamber **437** of the barrel **436**. A bore of the needle **432** is in communication with the chamber of the barrel. In use, the plunger **433** can be manually moved in a conventional manner to inject a desired amount of material into the subject small animal or to draw material thereinto the chamber of the barrel. In another example, the injector unit **430** also includes a conventional actuator **440** that is operatively coupled to the plunger **433**. In this example, the actuator **440** is also electrically coupled to a plunger control unit **442**. The user can actuate controls on the plunger

29

control unit **442** to retract or extend the plunger of the injector unit a desired amount.

The injector subassembly further comprises a needle insertion mechanism **540** constructed and arranged for controlling the extension and the retraction of the injector unit **430** relative to the mount member. In use, rotation of a needle insertion control knob **542** of the needle insertion mechanism moves the injector unit **430**, and the attached needle, bi-directionally along the seat and along longitudinal axis of the needle **432**. As one skilled in the art will appreciate, insertion or retraction movement of the injector unit and the attached needle depends upon the direction the needle insertion control knob **542** is moved.

It will be appreciated that the combination of the releasable coupling between the base members of the respective assemblies and the respective rails allows for repositioning of the assemblies while maintaining alignment and relative positioning of the various components. The assemblies can be set up and aligned in their respective procedure positions and subsequently moved out of position to, for example, replace the small animal on the table member. The assemblies can then be returned to their procedure positions to and be aligned in the same manner as for the previous small-animal on the table member. In this manner, it will be recognized that the potentially time-consuming process of re-aligning the assemblies can be avoided. Once the small-animal on the table member is imaged (and injected), a second small-animal can easily be introduced into the field of view with minimal adjustment to either the scanhead unit or, if used, the injector unit since the small-animal mount assembly can slide out of the image plane on its own rail.

The imaging system **10** can also comprise the computer **20** having a system processor **22**. The processor **22** can be coupled to a display or monitor **24** and to a user input device **26**, such as a keyboard, mouse, or other suitable device. If the monitor **24** is touch sensitive, then the monitor **24** itself can be employed as the user input device **26**. A computer readable storage medium **28** is coupled to the processor. As one will appreciate, the operation of the scanhead assembly **100**, table subassembly **210** of the small-animal mount assembly **200**, and, if used, the needle injection assembly **400**, could be operatively coupled to and controlled by the computer **20**. Further, if used, the scanhead articulation unit could be operatively coupled to and controlled by the computer **20**. As one skilled in the art will appreciate, the computer readable medium **28** can include hardware and/or software such as, by way of example only, magnetic disks, magnetic tape, optically readable medium such as CD ROM's, and semi-conductor memory such as PCMCIA cards. In each aspect, the medium **28** can take the form of a portable item such as a small disk, floppy diskette, cassette, or it can take the form of a relatively large or immobile item such as hard disk drive, solid state memory card, or RAM coupled to the processor **22**. It should be noted that the above listed example mediums **28** can be used either alone or in combination. The display **24** could be multipurpose and also serve as a screen for the imaging system **10**. Alternatively, the imaging system can have a separate screen.

Operation of the system begins by placing and securing the small animal onto the table member such that the small animal's paws are placed against the ECG pads. The rectal probe is inserted into the small-animal and the health parameters are monitored on the control apparatus **250** and/or the computer **20** throughout the imaging session. The respective controls of the mount subassembly of the small-animal mount assembly are selectively manipulated to place the table member in the desired table surface plane. In one

30

aspect, in the embodiment shown in FIGS. **45-48**, the small-animal mount assembly can be moved on the second rail until the plunger lock mechanism **206** engages a portion of the fixed stop **51** positioned intermediate the proximal and distal ends on the second rail. Alternatively, the small-animal mount assembly can be moved until a portion of the base member contacts a portion of a previously set movable stop on the second rail. In this position, the table member of the small-animal mount assembly is in the imaging field of the scanhead unit.

In one aspect, the mount of the scanhead assembly is positioned into a proximate procedure position on the first rail. In one aspect, the movable stop **50** is slid along and then secured onto the first rail at a desired procedure position that is within a few centimeters of the desired final procedure position of the mount. One will appreciate that fine adjustment to the position of the scanhead unit can be made through manipulation of the controls of the mount of the scanhead assembly. The mount of the scanhead assembly is moved into contact with the movable stop so that the desired image plane of the scanhead unit is positioned such that the image plane bisects the portion of interest in the small-animal.

In another aspect, illustrated in FIGS. **44-63**, the second rail is positioned relative to the first rail by selective positioning of the second rail base member. The small-animal mount assembly can be moved on the second rail until the plunger of the plunger lock mechanism **206** engages a desired position hole on the second rail. The magnetic lock of the orientation control mechanism releasably secures the bottom of the orientation control mechanism to the adjustable platform that is operatively connected to the base member. The controls of the orientation control mechanism are manipulated so that the height, tilt and rotation of the table member are adjusted such that the table member is positioned in the desired table plane. In this position, the table member of the small-animal mount assembly is in the imaging field of the scanhead unit.

In another aspect, the base member of the scanhead assembly is positioned and secured on a select portion of the first rail which proximates a procedure position on the first rail. The controls of the scanhead assembly are manipulated so that the scanhead unit is positioned in the desired table plane. As one will appreciate, in this position the table member of the small-animal mount assembly is in the imaging field of the scanhead unit.

As one will appreciate, when the imaging session is complete, the small-animal mount assembly and the imaging assembly can be moved away from the procedure positions on the first and second rails (toward the respective distal ends of the rails) while maintaining alignment and relative position of the small-animal mount assembly and the imaging assembly. Thus, the set image plane and the table surface plane will not change. A new small-animal can be positioned on the table member and the small-animal assembly and imaging assembly can be repositioned by relying upon the previous setting of the movable and/or fixed stops.

In an alternative aspect, shown in FIGS. **61-63**, the table/platform member on which the imaged small-animal can be removed by actuating the mount assembly and removing the table/platform member from the orientation control mechanism. In this aspect, a new small-animal, which is positioned on a second table/platform member can be rapidly mounted onto and secured to the orientation control mechanism and the small-animal mount assembly and the imaging assembly can be rapidly repositioned.

31

If the needle injection assembly is used, the injector unit is filled with the fluid to be injected. In one aspect, the base member of the needle injection assembly is positioned into a proximate procedure position on the third rail. In one example, the movable stop is slid along and then secured onto the third rail at a desired procedure position that is within a few centimeters of the desired final procedure position of the base member. One will appreciate that fine adjustment to the position of the needle of the injection unit can be made through manipulation of the controls of the carriage subassembly. The base member of the needle injection assembly is moved into contact with the movable stop and the controls of the carriage subassembly are manipulated so that the needle can be placed in the desired needle plane, which can also be the set image plane of the scanhead unit. The carriage subassembly can also be manipulated to select the desired angle of penetration of the needle within the desired needle plane.

In another aspect, shown in FIGS. 46, 64-67, the base member of the needle injection assembly is positioned and secured into a proximate procedure position on the first rail such that the small-animal mount assembly is positioned between the needle injection assembly and the imaging assembly. The controls of the carriage subassembly are manipulated so that the needle of the injection unit is positioned in the desired needle plane, which can also be the set image plane of the scanhead unit. The carriage subassembly can also be manipulated to select the desired angle of penetration of the needle within the desired needle plane.

The needle is advanced into the subject small-animal at the needle's insertion point to a desired depth and the sample material is injected either manually or by using the plunge control unit. Typically, confirmation of injected material, such as fluid, can often be seen on the screen of the system as the tissue surrounding the distal end of the needle accommodates the extra volume. The needle can then be withdrawn and the procedure is complete.

Subsequently, the needle injection assembly, the scanhead assembly, and/or the small-animal mount assembly can be selectively moved away from their procedure positions. A new animal can be positioned onto the table member of the small-animal mount assembly and the needle injection assembly, the scanhead assembly, and/or the small-animal mount assembly can be repositioned by relying upon the previous settings of the movable/fixed stops. Alternatively, as noted above, the table/platform member can be removed from the orientation control mechanism and another table platform member, holding a new animal, can be positioned onto the orientation control mechanism the small-animal mount assembly and the needle injection assembly, the scanhead assembly, and/or the small-animal mount assembly can be repositioned readily. One will appreciate that the planes of the scanhead unit and the injector unit will remain co-planer.

It is contemplated that many other procedures can be done using the imaging system 10 of the present invention. The multi-rail design of the imaging system enables an operator to precisely align the needle of the needle injection assembly within the imaging plane of the scanhead unit of the scanhead assembly. The needle injection assembly, the small-animal mount assembly, and the scanhead assembly can then be moved back and forth along their respective rails and be brought back to their original procedure positions without losing the alignment of the image plane or the co-planer alignment between the needle of the injector unit and the image plane of the scanhead unit.

32

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. An imaging system for imaging portions of small animals, comprising:

a first rail and a second rail, each having a longitudinal axis, wherein the second rail is connected to the first rail and is movable in a direction aligned with the longitudinal axis of the first rail, and wherein the second rail is rotatable with respect to the longitudinal axis of the first rail;

a small-animal mount assembly connected to the second rail and movable in a direction aligned with the longitudinal axis of the second rail; and

a scanhead assembly connected to the first rail and movable in a direction aligned with the longitudinal axis of the first rail, wherein the scanhead assembly is configured to orient a scanhead unit at a first orientation and at least a second orientation with respect to the small animal mount assembly.

2. The imaging system of claim 1, wherein the first rail is selectively mountable to a planar member, and wherein the planar member substantially underlies at least a portion of the first rail.

3. The imaging system of claim 1, wherein the second rail is rotatable with respect to the first rail such that the longitudinal axis of the second rail is oriented substantially perpendicular to the longitudinal axis of the first rail.

4. The imaging system of claim 1, further comprising: scanhead assembly base member configured to couple the scanhead assembly to the first rail; and

a needle injection assembly comprising an injection assembly base member that is selectively mountable onto the first rail such that the second rail is positioned between the scanhead assembly base member and the injection assembly base member, the injection assembly base member being constructed and arranged for movement in a linear bidirectional manner along the longitudinal axis of the first rail.

5. The imaging system of claim 1, wherein the first rail and the second rail further comprise:

a top surface;  
a first edge and an opposed second edge, each edge being substantially parallel to the longitudinal axis of the rail; and

a raised lip extending therefrom each edge of the rail, substantially perpendicular to the top surface.

6. The imaging system of claim 5, further comprising:

a scanhead assembly base member configured to couple the scanhead assembly to the first rail; and

a plurality of bearing members mounted on a bottom portion of the scanhead assembly base member, wherein at least one of the bearing members is disposed on a portion of the raised lip extending from the first edge of the first rail, and at least one of the bearing members is disposed on a portion of the raised lip extending from the second edge of the first rail.

33

7. The imaging system of claim 5, wherein the second rail further comprises a second rail base member, wherein the second rail base member comprises:

a plurality of bearing members mounted thereon a bottom portion of the second rail base member, wherein at least one of the bearing members is disposed thereon a portion of the raised lip extending from the first edge of the first rail, and at least one of the bearing members is disposed thereon a portion of the raised lip extending from the second edge of the first rail.

8. The imaging system of claim 5, further comprising:

a scanhead assembly base member configured to couple the scanhead assembly to the first rail;

a needle injection assembly comprising an injection assembly base member that is selectively mountable onto the first rail such that the second rail is positioned between the scanhead assembly base member and the injection assembly base member, the injection assembly base member being constructed and arranged for movement in a linear bidirectional manner along the longitudinal axis of the first rail; and

a plurality of bearing members mounted on a bottom portion of the injection assembly base member, wherein at least one of the bearing members is disposed on a portion of the raised lip extending from the first edge of the first rail, and at least one of the bearing members is disposed on a portion of the raised lip extending from the second edge of the first rail.

9. The imaging system of claim 1, wherein the scanhead unit is electrically coupled to a computer.

10. The imaging system of claim 1, wherein the scanhead assembly further comprises:

a third rail having a longitudinal axis and extending upwardly away from a scanhead assembly base member, the third rail having a distal end;

a cantilever base member mounted thereon the third rail, the cantilever base member being constructed and arranged for linear bi-directional movement along the longitudinal axis of the third rail, the cantilever base member having a rail lock assembly for selectively securing the cantilever mount member at a desired position in relation to the third rail;

a fourth rail having a longitudinal axis and a first end, the fourth rail being slidably mounted to the cantilever base member, wherein the fourth rail is constructed and arranged for linear bi-directional movement along its longitudinal axis with respect to the cantilever base member;

a scanhead unit orientation control mechanism connected to a portion of the first end of the fourth rail and a portion of the scanhead unit, the scanhead unit orientation control mechanism constructed and arranged to position the emitting end of the scanhead unit in a desired image plane.

11. The imaging system of claim 10, further comprising a scanhead articulation unit selectively mounted therebetween the scanhead unit orientation control mechanism and the scanhead unit, wherein the scanhead articulation unit comprises:

a motor mount having a proximal end mounted to the scanhead unit orientation control mechanism, the motor mount defining a bore;

a motor assembly mounted thereon a portion of the motor mount having a driven tube, wherein the driven tube is co-axial with the bore of the motor mount and wherein the driven tube comprises a threaded interior surface;

34

a threaded rod, having two ends, constructed and arranged to engage the threaded interior surface of the driven tube of the motor assembly, the threaded rod having a longitudinal axis substantially transverse to the desired image plane, wherein rotating the driven tube moves the threaded rod along its longitudinal axis with respect to the motor mount; and

a saddle member, having two opposed sides and a floor extending therebetween, mounted thereon the threaded rod such that the ends of the threaded rod rotatably engage the two opposed sides of the saddle member, the scanhead unit being mounted to and extending therefrom a bottom portion of the floor such that the movement of the threaded rod along its longitudinal axis results in selective bidirectional movement of the bottom portion of the floor of the saddle member about an axis parallel to the longitudinal axis of the threaded rod which, in turn, moves the emitting end of the scanhead unit, thereby moving the image plane along a movement axis substantially parallel to the longitudinal axis of the threaded rod.

12. The imaging system of claim 11, wherein the motor mount further comprises an elongate beam member attached to a distal end of the motor mount, the beam member being substantially transverse to the longitudinal axis of the motor mount and substantially parallel to the longitudinal axis of the threaded rod, wherein the beam member comprises a bearing surface along its longitudinal axis.

13. The imaging system of claim 12, wherein the saddle member further comprises a bearing attached thereon a top portion of the floor, the bearing operatively engaging the bearing surface of the beam member.

14. The imaging system of claim 13, wherein the motor assembly is electrically coupled to a computer.

15. The imaging system of claim 10, wherein the scanhead assembly further comprises an upright rod member rotatably mounted substantially parallel to the longitudinal axis of the third rail, wherein the rod member further comprises a threaded surface, and means for rotating the rod member such that the cantilever base member is selectively movable, bi-directionally, along the longitudinal axis of the third rail.

16. The imaging system of claim 15, wherein the cantilever base member defines a threaded bore sized and shaped for complimentary engagement with the threaded surface of the rod member and wherein the means for rotating the rod member comprises a gear assembly in communication with one end of the rod member.

17. The imaging system of claim 16, wherein the scanhead assembly further comprises a gear assembly housing mounted thereon the scanhead assembly base member, wherein the third rail is connected to the gear assembly housing and extends therefrom substantially transverse to the longitudinal axis of the first rail, and wherein the gear assembly is housed within the gear assembly housing.

18. The imaging system of claim 17, wherein the scanhead assembly further comprises an upright column member extending upwardly away from the scanhead assembly base member, wherein the gear assembly housing is mounted thereto a top of the upright column member and wherein a longitudinal axis of the upright column is substantially parallel to the longitudinal axis of the third rail.

19. The imaging system of claim 1, wherein the small-animal mount assembly further comprises:

a table member having a top surface, a bottom surface, and defining a table plane;

a platform member having a top face and an opposed bottom face, the bottom surface of the table member being mounted thereon the top face of the platform member;

a means for orienting the table member so that the table plane of the table is positioned in a desired table plane; and

a means for releasably mounting the platform member to the means for orienting the table member.

20. The imaging system of claim 19, wherein the small-animal mount subassembly further comprises:

a planar platform having an upper surface and a lower surface and defining a first axis parallel to the longitudinal axis of the second rail and a second axis normal to the first axis, the platform further defining a platform plane defined by the first axis and the second axis; and

a platform adjustment assembly constructed and arranged for moving the platform in the platform plane, the platform adjustment assembly having a platform base and an adjustable armature, the platform base being connected to a portion of a top surface of the mount subassembly base member and the armature being connected to a portion of an edge of the planar platform.

\* \* \* \* \*

25